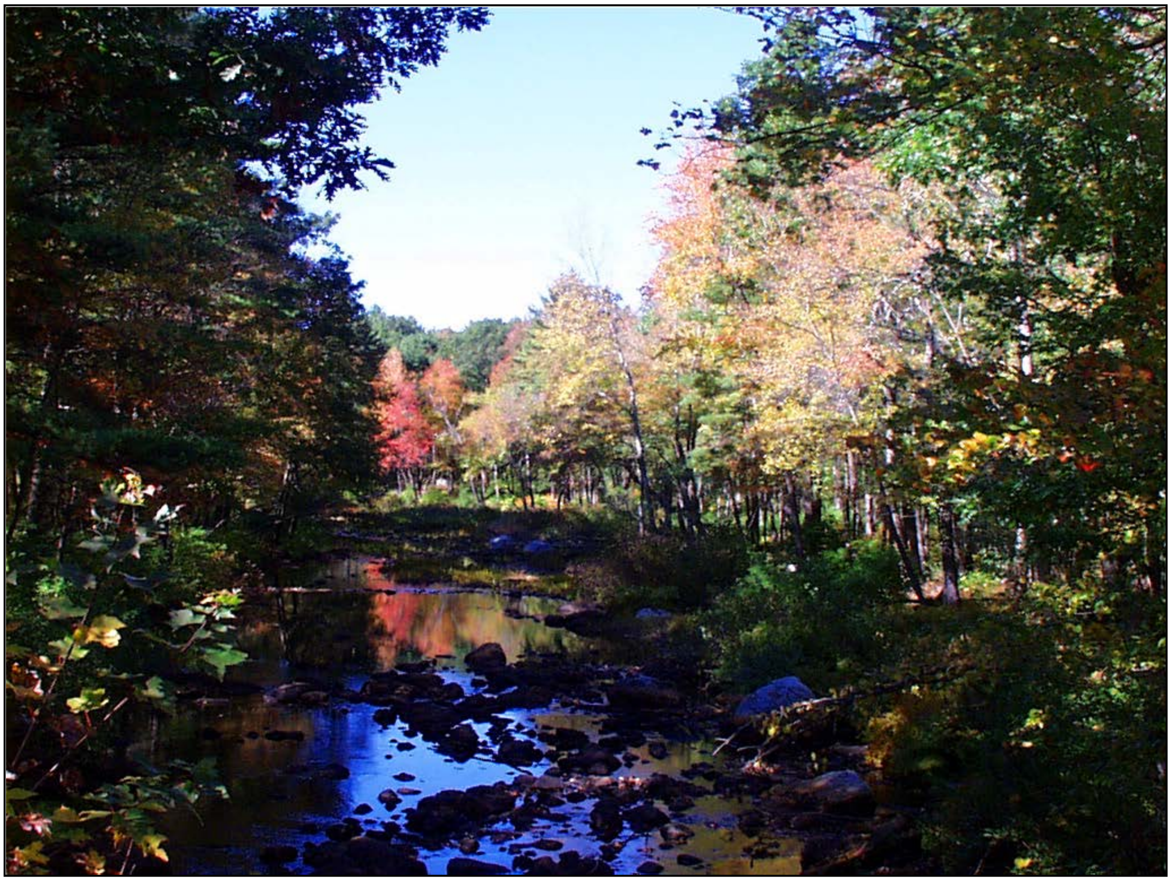
Ware River Watershed
Land Management Plan 2003-2012

Prepared by

Department of Conservation and Recreation
Division of Water Supply Protection



November 10, 2003

Commonwealth of Massachusetts
Mitt Romney, Governor

Executive Office of Environmental Affairs
Ellen Roy Herzfelder, Secretary

Department of Conservation and Recreation
Katherine Abbott, Commissioner

Division of Water Supply Protection
Joseph M. McGinn, Esq., Acting Director

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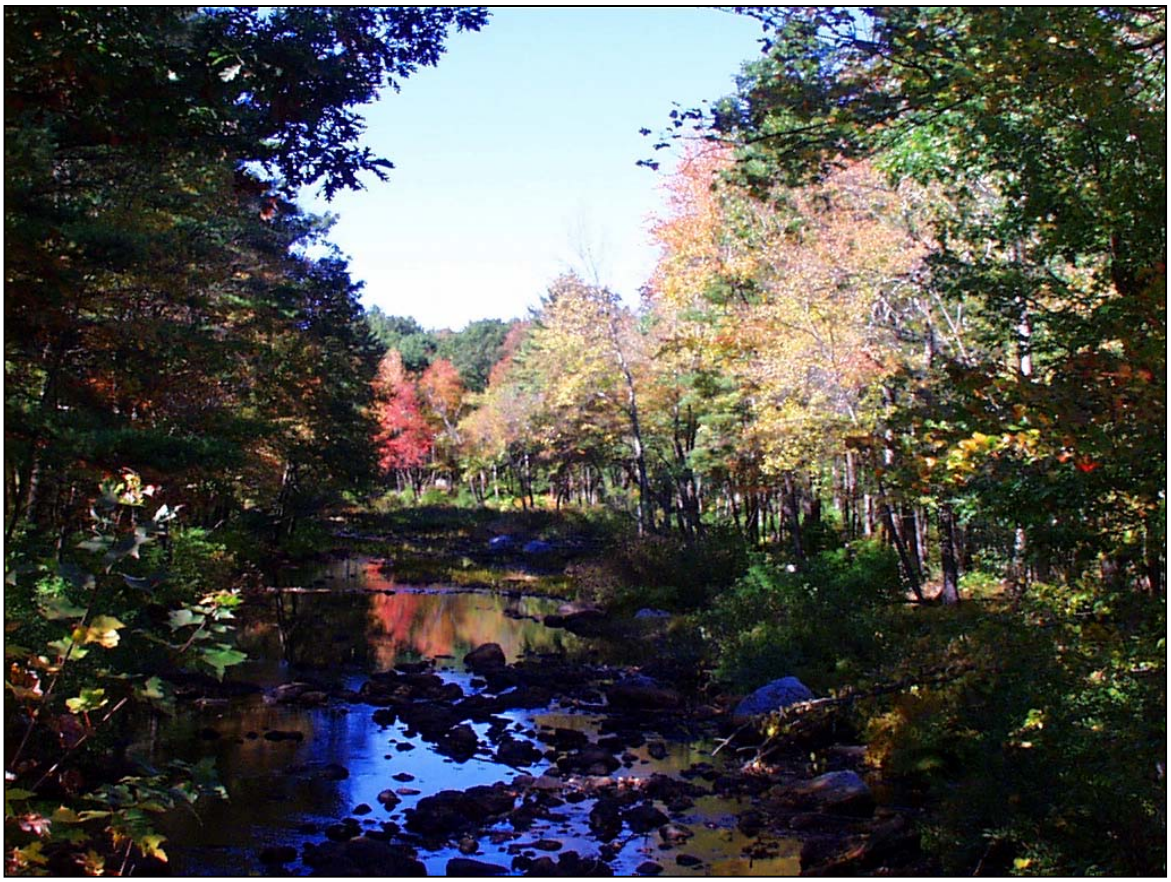

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Dedication

Stephen L. Drawbridge
1947-2002

Stephen Drawbridge, better known as Steve, was the MDC Forester on the Ware River Watershed from 1978 to 2002, a total of 24 years. Steve was a perfect match for the Ware River and it seemed that other forces were at work to make this happen. Steve grew up in nearby Holden and was familiar with these lands due to his hunting and fishing interests.

Prior to 1978, there had been several MDC Foresters at the Ware River, but none had stayed more then a few years. The Ware River forest consisted largely of low grade pasture pine stands and hardwood stands growing generally on low production, washed till soils. All the roads were open to the public and most were in poor condition. Illegal dumping was commonplace. Managing the Ware River Watershed was a challenging job.

When interviewing for the Ware River Forester's position in 1978, Steve stood out because of his excellent qualifications and his abundant enthusiasm and energy. I did not know Steve well, so I asked Roger Lonergan, the MDC engineer in charge at the Ware River, what he thought about Steve. Roger was a quiet Yankee who seldom offered an opinion on anything except perhaps bird hunting, fishing, or diverting water from the Ware River. Roger was familiar with Steve's family background and his interest in becoming the Ware River forester and without hesitation, Roger strongly suggested that we hire Steve.

Steve loved every aspect of his work and continued to be a student of forestry, wildlife, recreation, cultural resources, aesthetics and the social aspects of natural resources so that his management strategies were comprehensive. It was my pleasure to travel about the Ware River lands to view Steve's work. Steve's forestry and landscape architecture were both bold and discrete but fit on the land as a tailored suit.

Steve orchestrated an annual Ware River hunt for white-tailed deer. He patiently gave his friends knowledge of every topographic and cover feature that we would encounter in the hunt. This physical knowledge plus his uncanny knowledge of the ways of deer made each hunt memorable.

Most of all Steve was a true friend, someone I could talk to, on any subject, without concern. We had endless conversations about forestry, hunting, logging, watershed management, sports (hockey and basketball), and family. Although we did not always agree, we led each other on challenging topics as our thinking evolved.

Steve spent several years on this plan and was working on the final draft when he passed away. But a final draft for Steve was almost an impossible thought, simply because his inquiring mind was constantly finding new information that he wanted to incorporate. Steve's thoughts and convictions are as much a part of this plan as is his work on the ground throughout the Ware River Watershed. As you read this plan, you will come to understand how lucky we were to have known and worked alongside Steve Drawbridge for the past 24 years. We are privileged to have had the opportunity to finish a plan he started, and we dedicate this 2003-2012 Ware River Watershed Land Management Plan to Steve's memory.

Bruce A. Spencer
Chief Forester
2/10/03

Acknowledgements

The Ware River Watershed Land Management Plan for 2003-2012 was prepared by the Natural Resources and Quabbin Section Forestry staffs of the Department of Conservation and Recreation, Division of Water Supply Protection. Plan sections were drafted by many authors, including Steve Drawbridge (Forester II, Quabbin Section), Herm Eck (Forester I, Quabbin Section), Bruce Spencer (Forester III, Quabbin Section), Dan Clark (Conservation Biologist, Natural Resources Section), Thom Kyker-Snowman (Natural Resources Specialist, Natural Resources Section), Peter Church (Director, Natural Resources Section), Marcheterre Fluet (Regional Planner 1, Natural Resources Section), Matt Hopkinson (Environmental Analyst, Quabbin Section), Dave Small (Forest and Park Regional Supervisor, Quabbin Section), Jim French (Land Acquisition Coordinator, Natural Resources Section), and Joel Zimmerman (Regional Planner II, Division Staff). Philip Lamothe (GIS Specialist, Quabbin Section) assisted Marcheterre Fluet in producing the maps and other GIS illustrations throughout the plan Photos were provided by Marcheterre Fluet, Thom Kyker-Snowman, Dan Clark, Steve Drawbridge, Herm Eck, Dave Small, and Clif Read (Supervisor, Interpretive Services). Detailed review and comment were provided by the staff above, as well as by Joe McGinn, Esq. (Acting Director, Division of Water Supply Protection), Bill Pula (Superintendent, Quabbin Section), Bob Bishop (Environmental Analyst, Quabbin Section), Lisa Gustavsen (Environmental Analyst, Quabbin Section), John Scannell (Superintendent, Wachusett Section), Greg Buzzell (Forester II, Wachusett Section), Brian Keevan (Forester I, Wachusett Section), Paul Lyons (Natural Resource Specialist, Natural Resources Section), Sandra Pineyro (Executive Office of Environmental Affairs), and Bob O'Connor (Director of Forest and Land Policy, Executive Office of Environmental Affairs).

This plan was distributed in draft form, for review and comment, to approximately 75 individuals, agencies, and organizations outside the Division. This list included the Executive Office of Environmental Affairs, the Massachusetts Water Resources Authority, the Water Supply Citizen's Advisory Committee, the Ware River Advisory Committee, the Massachusetts Division of Fisheries and Wildlife, the Massachusetts Division of State Parks and Recreation, the Massachusetts Department of Food and Agriculture, the Massachusetts Department of Environmental Protection, the University of Massachusetts Department of Natural Resources Conservation, the US Army Corps of Engineers, the USDA Forest Service, the Conservation Commissions and public libraries in area towns, District Representatives and State Senators, and a wide variety of other interested individuals. Comments received in writing and at a public meeting on September 23, 2003, have been incorporated in this final version of the plan.

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ACRONYMS and ABBREVIATIONS

BMP: Best Management Practices

CMP: Conservation Management Practices

CR: Conservation Restriction

CVA: Chicopee Valley Aqueduct

DCR: Department of Conservation and Recreation

DEM: Department of Environmental Management

DEP: Department of Environmental Protection

DFWELE: Department of Fisheries, Wildlife, and Environmental Law Enforcement

DFW: Division of Fish and Wildlife

DPW: Department of Public Works

DSPR: Division of State Parks and Recreation

DUPR: Division of Urban Parks and Recreation

DWM: Division of Watershed Management

DWSP: Division of Water Supply Protection

EOEA: Executive Office of Environmental Affairs

EPA: Environmental Protection Agency

GIS: Geographic Information System

MDC: Metropolitan District Commission

M.G.L.: Massachusetts General Law

MWRA: Massachusetts Water Resources Authority

PILOT: Payments In Lieu of Taxes

QSTAC: Quabbin Science and Technical Advisory Committee

WRAC: Ware River Advisory Committee

Executive Summary

1 Introduction, Mandates, and Statement of Mission

Contents: The legislative mandates, agency mission statements, and other foundations for DCR's land management program. Also included are a general overview of this management plan, its relationship to past MDC/DWM plans and future DCR/DWSP plans, and a description of the planning process.

Key Points:

Chapter 372 (Acts of 1984) provided the primary legislative mandate for the Metropolitan District Commission's land management activity. Chapter 372 established the Division of Watershed Management and directed it to "…utilize and conserve…water and other natural resources in order to protect, preserve and enhance the environment of the Commonwealth and to assure the availability of pure water for future generations." This statute sets forth clear authority for the active management of the watershed and its natural resources. Chapter 372 directs the MDC/DWM to periodically prepare watershed management plans for "…forestry, water yield enhancement and recreational activities."

On June 30, 2003, Governor Romney signed legislation merging the Metropolitan District Commission (MDC) and the Department of Environmental Management (DEM) into the new Department of Conservation and Recreation (DCR). Since July 1, 2003, The Department of Conservation and Recreation / Division of Water Supply Protection (DCR/DWSP) has assumed the MDC/DWM responsibilities mandated by Chapter 372.

The Ware River Watershed Land Management Plan 2003-2012 calls for the maintenance of a diverse, multi-layered forest cover on much of the watershed. The plan primarily focuses on management over the next ten years, but it also projects the forest cover and watershed conditions 60 years into the future. This plan should be viewed as an "adaptive watershed management plan" to be applied but updated and modified as new properties are added and new information becomes available.

Public input is an important component in the effective management of DCR/DWSP properties; it is sought throughout the planning process. In addition, a volunteer group of scientific and technical advisors provide their expertise to the DCR/DWSP.

2 Background: Ware River Watershed

Contents: A broad overview of the physical characteristics of the Ware River watershed, including the land use history of this area and its impact on the present landscape.

Key Points:

The Ware River Watershed lies in the Central Uplands in north central Massachusetts, and is characterized by rolling hills separated by broad river valleys. The watershed above the Intake Works at Shaft #8 covers 96.8 square miles, or 61,952 acres. It encompasses parts of eight towns: Barre, Hubbardston, Oakham, Phillipston, Princeton, Rutland, Templeton and Westminster. The Department of Conservation and Recreation, Division of Water Supply Protection controls 23,694 acres of Commonwealth-owned land in the Ware River watershed. The Commonwealth holds Conservation Restrictions (CRs) on an additional 787 acres.

Bedrock of the Ware River watershed consists of high-grade complexly folded metamorphic rock heavily intruded by pegmatite. The bedrock is separated into three formations: Partridge Formation, Paxton Formation, and Littleton Formation. Exposure of the bedrock is limited because it is veneered by glacial drift consisting of till and outwash.

Ware River soils have been grouped into five classes for the purpose of watershed management, based upon soil depth and drainage characteristics: Excessively Drained Soils, Well Drained Thin Soils, Well Drained Thick Soils, Moderately Well Drained Soils, and Poorly to Very Poorly Drained Soils.

The average annual stream flow recorded at Shaft #8 and the weir below has been 39.3 billion gallons, or 53% of the average annual precipitation (MDC/MWRA records). At the Intake Works, the Ware River is a 4th order stream formed by the convergence of seven major tributaries which travel a total of about 77 miles to the Intake Works. Sixteen ponds scattered over the watershed range in size from about 30 acres to over 100 acres. The DCR controls the entire shoreline on four of these, and part of the shoreline on an additional five ponds. Wetlands account for more than 3,500 acres on DCR/DWSP lands in the Ware River watershed. They include coniferous and deciduous wetlands as well as those dominated by shrub and herbaceous cover. Over the past decade there has been a shift from forested wetlands to shrub and open wetlands as a direct result of an increase in beaver activity.

European settlement of the region began in 1715, and within a century most of the pre-existing forest had been cleared for agricultural purposes. Since the 1830s, most of this agricultural land has been abandoned, resulting in a steady conversion from open agricultural habitat to forest cover, first dominated by white pine, and then, following broad-scale harvesting of the pine, mixed hardwoods and pine.

This region has experienced significant population growth in the past 20-30 years and consequently continues to be subdivided and developed for residential and commercial use. Average private ownership parcel size has decreased steadily as a result.

The forest that presently covers most of the Division holdings at the Ware River is a product of: 1) natural succession following agricultural abandonment, 2) heavy cutting (mostly white pine) 60-100 years ago and 3) MDC forest management activities over the past 30 years. The legacy of both social and environmental factors is apparent in the forest as it exists today.

3 Water Resources

<u>Contents</u>: An historical perspective on water resources in the Ware River watershed, a description of the Ware River Intake Works, and information on the surface waters and water yield and quality.

<u>Key Points</u>:

Chapter 321 of the Acts of 1927 authorized construction of the Quabbin Reservoir and the Ware River intake. The Intake Works and the Coldbrook-Wachusett aqueduct were completed in 1931. In that initial year, approximately thirteen billion gallons of water were diverted from the Ware River to the Wachusett Reservoir.

The impoundment at Roger Lonergan Intake at Shaft No. 8 in Barre is classified as a "run of the river reservoir." Residence time is short and the water derives its character from water inputs including Barre Falls Dam, the Burnshirt River, Natty Pond Brook, and Parker Brook, as well as subsurface flow and small amounts of direct overland runoff from impervious surfaces. Each of these inputs contributes markedly different qualities to the water at the Intake. Besides the impoundment at the Intake, the DCR owns or controls many small dammed ponds that were originally built to provide power for mills.

The Intake Works at Shaft No. 8 are a siphon system. Water is drawn from above the dam into the Works through six siphon spillways. From the spillways the water enters the valve pit where four butterfly valves are mounted to regulate the amount of water entering the shaft. The large metered valve has a capacity of 620 million gallons daily, while each of the three unmetered valves has capacity of slightly less than 600 million gallons a day. The total capacity is slightly less than 2.4 billion gallons daily. The valves direct the water onto cast iron plates with helical vanes mounted on the walls of the shaft. Centrifugal force maintains a smooth discharge of water from the valves around the circumference of the shaft. The water can then be gravity-fed through the aqueduct to either the Quabbin or Wachusett Reservoir. Diversion normally goes to Quabbin, where a baffle dam forces the highly organic water diverted from the Ware River to flow around Mt. Zion, being mixed and stored with the less organic water of the Swift River before leaving Quabbin Reservoir.

Legal restrictions governing diversion of water from the Ware River require that:

- No water may be diverted from the Ware River on any day when the natural flow of the river is less than eighty-five million gallons.
- A total of eighty-five million gallons of water must be released down the Ware River on each day during which diversion takes place.
- No diversion shall take place during the period between May 31 and December 1 in any year unless such diversion is first approved by the State Department of Public Health.

While water quality considerations will drive management decisions for this 2003-2012 Ware River Land Management Plan, both water quality and water yield will remain important considerations in land management planning.

4 Land Protection

Contents: A quantification of protected land ownership within the Ware River watershed. Also a description of DCR/DWSP assistance in the protection of privately-owned and community-owned land, including Conservation Restrictions and Payments In Lieu of Taxes (PILOT).

The DCR/DWSP-owned lands on the Ware River watershed are placed in the context of the entire DCR watershed system. Protection of DCR/DWSP-owned land is detailed, including boundaries, fire, roads, transfers, rights-of-way, disposition, and acquisition.

Key Points:

DCR controls approximately 23,694 acres, or 38.2%, of the Ware River watershed above Shaft 8. There is a long history of cooperation among those agencies concerned with the Ware River watershed, including the Division of Fisheries and Wildlife, the Army Corps of Engineers, and the MA Department of Environmental Management (now the DCR Division of State Parks and Recreation).

There are approximately 125 miles of DCR/DWSP boundary on the Ware River watershed, most traversing remote areas between paved roads. Boundary encroachments on DCR/DWSP property include destruction of property, impairment of water and soil, and construction. Maintained, visible boundaries protect the integrity of property, provide a frame of reference for policing and monitoring, and are essential proof when a dispute or encroachment occurs. Due to current staffing considerations, the Division is considering contracting out boundary maintenance, or using seasonal employees for this work. In either case, the Division engineering staff would have responsibility for supervision of boundary maintenance.

The number of MDC (now DCR) Rangers assigned to the Quabbin/Ware River watersheds has grown since 1996 from one to seven. Ranger patrols include pro-active surveillance of DCR/DWSP-controlled lands with emphasis on popular access locations around the Ware River watershed. Presently, Watershed Rangers spend an average of 16-20 hours per week covering responsibilities on the Ware River watershed.

The DCR has care and control of approximately 57 miles of gravel access road on the Ware River watershed, as well as numerous miles of non-gravel road. The objectives of road maintenance on DCR watershed lands are to provide for vehicle access to support key watershed management activities, and to minimize adverse water quality impacts associated with this road system. Activities that are dependent upon a good access road system include fire protection, forest management, water sampling, research, and ranger patrols. These activities require stable, properly shaped and ditched road surfaces with adequate structures to manage stormwater. Some DCR/DWSP roads at Ware River are experiencing more traffic than they are capable of handling without deterioration. The Division intends to reduce unofficial use of its roads to a level that can be sustained by current maintenance staff and equipment.

The DCR fire policy, in conjunction with better coordination between DCR, the Division of State Parks Recreation, and local fire departments, has improved fire response time and suppression efforts. DCR provides assistance to the local fire departments as directed by the local fire chief, usually for "mop up" operations. At present, twenty-three DCR employees are certified and available to participate in fire suppression operations. Improvements in fire suppression have been aided by the acquisition of new fire fighting apparatus and at the Ware River by improvements in gravel access roads and by controlling public vehicle access through installation of security gates, thereby reducing the threat of ignition by recreational users.

The MDC acquired 3,255 acres (2,715 in fee & 540 in conservation restrictions) on the Ware River watershed between 1985 and June 2003, bringing the total holdings to 23,694 acres (including 787 acres in CRs), or 38.2% (up from 31.3% in 1985) of the watershed. Expenditures for this acreage total $12.3 million. Funding for the watershed land acquisition program has come from the 1983 Open Space Bond ($3 million), the 1987 Open Space Bond ($30 million), and the Watershed Protection Act of 1992 ($135 million). Approximately $15 million remains available for land purchases ($3 million per year through 2008) within the watershed system. Most of these funds will be spent purchasing land on the Wachusett watershed, which is the least protected basin, with 26% under Division control. Future Ware River watershed land acquisition efforts will focus primarily on the Burnshirt and Canesto River subwatersheds, and Natty Pond Brook subwatershed.

Conservation restrictions constitute a partial acquisition of rights to land ownership, usually in the form of development restrictions. In these cases, the DCR agrees to acquire limited rights to property and to record these rights as an attachment to a landowner's deed. The landowner remains the owner and retains all rights to ownership except those described in the easement. Any easement acquired by the DCR for watershed protection must help insure the maintenance of a pure public drinking water supply. To this end, it is the policy of this agency to expend funds for the purchase of conservation easements only on acreage with uses, both present and projected, that do not conflict with this goal.

MGL Ch. 59, §5G requires the Commonwealth to make Payments In Lieu of Taxes (PILOT) on properties acquired for watershed protection. This law took effect for Ware River watershed lands in

1987. The state lands revaluation concluded in June 2000 by the Department of Revenue placed the value of Division-controlled property in Ware River watershed communities at $51 million, 80% greater than the 1995 valuation. This increase, which took effect with the FY2001 PILOT, reflects both the additions in Division land ownership (particularly of valuable “prime lots” that could have been developed) and the rise in property values throughout the watershed. The PILOT program, starting in FY2001, annually distributes a minimum of approximately $725,000 to the Ware River watershed communities.

The DWSP seeks common ground on resource protection issues by working with watershed area officials and citizens, since combined efforts help protect both local resources and the metropolitan Boston water supply. The technical assistance programs emphasize local source protection and its immediate impact to watershed residents and decision-makers. Through a cooperative approach, the DWSP improves land-use planning, control of development, and general environmental protection at the local level.

The DWSP Private Lands Stewardship Program encourages private landowners to manage their forests and wildlife to meet watershed-wide goals, looking beyond their individual property boundaries and designing management strategies that address the issues of the larger ecosystem. As of May 2003, 65 private properties totaling 4,556 acres had completed 10-year forest management plans with assistance from this program. Thirteen of these properties are located within the Ware River watershed, totaling 803 acres. The average cost to the Division to provide watershed protection through private land management plans is approximately $12 per acre.

5 Management of Forested Lands Controlled by DCR

Contents: An extensive description of the past, present, and planned management of DCR forests on the Ware River watershed. Division goals and objectives for forest management on the Ware River watershed are described in detail, as are the silvicultural practices chosen to address Ware River forest management objectives. The implementation of a three-strategy approach to forest management on the Ware River watershed is defined and evaluated. Conservation Management Practices (CMPs) designed to protect water supplies are described.

Key Points:

The Metropolitan District Commission purchased the major portion of its present holdings on the Ware River watershed, for the purpose of drinking water supply protection, between 1927 and 1940. At the time of purchase, land use/land cover in the area was a combination of active agricultural land, abandoned fields, and forest land. Approximately 1,700 acres were planted to white, red, and Scotch pine, Norway and white spruce, and European larch between 1931 and 1945. The first harvest operations conducted on Commission-controlled lands were salvage operations of timber damaged by the hurricane of 1938. Continuous Forest Inventory (CFI) plots were established at the Ware River watershed in 1962 by MDC Forest and Park Supervisor Fred Hunt, who established the first CFI plots at Quabbin Reservoir in 1960. The first formal forest management plan for the Ware River was written by MDC Forester Stephen Drawbridge in 1983. Between 1978 and the present, several thousand acres of low quality pasture pine stands have either been regenerated to mixed oak/pine and oak/hardwood stands, via overstory removal cuts, or left as pine stands but improved by cutting the least vigorous or most poorly-formed trees. The improved vigor, increased oak component, and greater age and species diversity have collectively made the watershed forest more resistant to and resilient.

Nearly all of the uplands controlled by the Division on the Ware River watershed are forested, with the remainder in field. The current forest on Division lands on the Ware River watershed is made up of a range of low to high quality stands, both managed and unmanaged, with an abundance of forest regeneration. Ninety-four percent of the forest is more than sixty years old, and sixty percent is over eighty years old. Some older stands also have an age class that originated with the hurricane of 1938, making them two-aged. A small portion of the forest area is comprised of plantations, established by MDC personnel in the 1930s and 1940s. White, red, and Scotch pine, Norway and white spruce, and European larch were planted as monocultures or in various mixtures. Most of these plantations have been converted to open land or regenerated to natural stands. The largest portion of the forest originated from agricultural lands abandoned in the late 1800s and early 1900s. These developed as understocked white pine stands ("old field white pine") that matured into low quality mixtures of pine and hardwood. Most are even-aged stands, but in some there is a remnant of trees that were present in the original pasture or trees that regenerated following the 1938 hurricane, giving them a two-aged or multi-aged structure.

The guiding objective for the Division's Ware River silvicultural practices is the creation and maintenance of a watershed protection forest, defined by the Society of American Foresters as "an area, wholly or partly covered with woody growth, managed primarily to regulate stream flow, maintain water quality, minimize erosion, stabilize drifting sand or exert other beneficial forest influences" (SAF, 1983). The silvicultural system chosen for the watershed protection forest at Ware River includes intermediate cuttings, regeneration establishment cuttings, and cuttings to release established regeneration.

While the Ware River is administered as part of the Quabbin Section, it has some unique features that affect land management policy. The absence of a reservoir, limited periodic use of the water, and a prolonged time separation from the consumer has engendered a different land management history, including the accommodation of limited secondary uses. The status of the Ware River as part of the supply system has not changed and the Division continues to choose forest management options that are efficient and provide a high level of water supply protection.

For the period covered by this plan, the principal goals for the management of Division properties on the Ware River watershed are to:

- Provide a vigorous forest cover, diverse in species composition and tree sizes and ages, and therefore able to resist and recover from disturbance and to retain available nutrients.
- Maintain the ability of the forest to regenerate following disturbance.
- Prevent erosion of sediments and nutrients from the watershed forest through carefully applied Conservation Management Practices.
- Provide long-term water quality protection with minimal intervention by developing a vigorous, low-maintenance forest.
- Comply with or exceed all environmental regulations governing forest management activities and water resources protection on Division watershed properties.
- Apply forest management practices that maintain current water yields from the watershed.
- Without compromising primary goals for water quality protection, promote the secondary goals of improving the growth and quality of the forest resource, protecting and enhancing habitat for native wildlife species, and maintaining and enhancing biological diversity.

Because the Division's primary forest management objective is water quality protection, silvicultural treatments are designed to create and maintain vigorous forest cover that both resists and recovers from a wide range of disturbances. Improving the structure and composition of stands will reduce their susceptibility to disease, insects, and disturbance, creating a low-maintenance, persistent forest cover. In the present management period (2003-2012), treatments are planned to:

- Increase the structural diversity of the forest.
- Establish regeneration as necessary, and release advance regeneration.
- Regenerate approximately 1% of the managed forest annually.
- Replace softwood plantations with diverse mixes of native species.

While MDC's silvicultural practices over the years have produced substantial revenue that currently approaches $1 million annually, revenue production has never been a primary objective of these practices. Within this framework, MDC foresters have been able to practice forestry with equal attention to harvesting and to the protection and enhancement of the resources remaining once the harvest is complete. Over decades of applying these forestry practices, the watershed forests have increased in value, both economically and as protection for the drinking water supply, without compromising their broader ecological functions.

The approach adopted for the management of the forest at the Ware River includes three strategies, which will guide management in different areas. As a group these strategies give Division foresters flexible tools with which to address the primary objective of water quality protection as well as a variety of secondary concerns such as biological diversity and aesthetics. They also match the intensity of the silvicultural practices to the sensitivity of resource areas to these activities. Strategy One will eliminate silvicultural operations in sensitive portions of the forest. Strategy Two will employ appropriate silvicultural treatments in areas where silviculture is limited by regulation, including riparian filters and roadside buffer areas. In Strategy Three, all described types of silviculture will be employed to address a range of management and habitat goals, in which water quality protection is paramount.

The major forest types occurring on the DCR properties on the watershed are described, as well as the silvicultural needs of these types, which will be adjusted according to the overlap between forest type and management strategy for any given stand.

Natural disturbances in a forest occur at virtually all scales of time and area. The uneven-aged forest, with three or more age classes well distributed across the landscape of the Ware River watershed, is considered best able to resist and recover from both large and small scale natural disturbances.

Although the Division does not intend to salvage following every disturbance, salvage activities are important components of watershed maintenance when the disturbance damages large areas of forest, or greatly increases the threat of additional damage. Disturbances in areas that are small, remote, or inaccessible may be left to regenerate on their own, although trees may be planted to enhance recovery of these areas.

The DCR/DWSP's Conservation Management Practices (CMPs) ensure that forest management is conducted in a manner that does not impair water resources or other natural or cultural resources on the watersheds. The Division meets or exceeds the requirements of both the Forest Cutting Practices Act and the Wetlands Protection Act (MGL ch. 132 and 131). Whenever these regulations are revised, DWSP management practices will meet or exceed the revised standards.

The Division has established an annual review procedure for all DCR forest management activities on the Ware River watershed involving DCR staff from supporting disciplines include wildlife biology, forest planning, water quality and environmental engineering, civil engineering, and cultural resource protection.

6 Wildlife Management

Contents: An overview of the Ware River watershed wildlife community, DCR/DWSP wildlife management goals and objectives, and Conservation Management Practices (CMPs) for wildlife management. A detailed assessment of the anticipated impacts of planned watershed management activities. Section also includes a discussion of wildlife population or impact control plans.

Key Points:

The Ware River watershed supports an impressive variety and abundance of wildlife. DWSP forests provide habitat for a diversity of birds and mammals including moose, white-tailed deer, turkey, grouse, fisher, and bears. Neotropical migratory birds utilize Division forests for breeding and as migratory rest stops. Wetlands support a variety of reptiles, amphibians, and birds. Several multi-acre tracts of early successional non-forested habitat provide habitat for a variety of species dependent on open lands, including eastern meadowlarks, bobolinks, and various insects. Since some towns within the watershed are experiencing tremendous growth, open space is being rapidly converted to residential areas. The protection that Division lands provide to wildlife species may be critical to their long-term survival.

The primary goal of the wildlife program on the Ware River watershed is to protect water quality from negative impacts associated with wildlife. The specific objectives of the wildlife management program are to:

- Mitigate adverse impacts of wildlife on water quality, infrastructure, and other watershed resources.
- Protect uncommon, rare, and otherwise significant wildlife species and habitats wherever they exist on DCR lands.
- Assess and mitigate impacts of watershed management activities on wildlife through a process of notification, site visits, review of records and literature, and recommendations to appropriate management staff.
- Actively manage for selected wildlife species that are considered to be uncommon, rare, or unique on a regional or statewide basis.

Conservation Management Practices (CMPs) for wildlife management include: the identification and protection of all vernal pools, seeps, springs, and surrounding soils; the retention of old apple and other fruit trees when possible; and the preservation of functional wildlife wintering areas. In addition, a variety of mast-producing plants will be maintained and enhanced within the watershed, including both hard mast producers such as oaks and hickories, and soft mast producers such as blueberries and dogwoods. Forestry operations will continue to provide both den and snag trees, deliberately distributed in order to maintain self-sustaining populations of all cavity-dependent wildlife. Downed woody material will be retained or provided in a range of sizes and types. DCR/DWSP will maintain suitable nesting sites for woodland raptors across the landscape over time and will avoid disturbing nesting pairs of raptors.

The planned silvicultural treatments to diversify age and species structure of DCR watershed forests will result in wildlife communities dominated by species adapted to a variety of forested conditions. Those species requiring early successional non-forested habitat will be less common and restricted to those limited areas where this type of habitat exists. Open, non-forested habitat will be maintained on a small percentage of the Division's land on the Ware River watershed. In general, wildlife species adapted to forest cover should benefit the most from the Division's land management plan for its Ware River watershed properties.

While it is the Division's policy not to interfere with natural wildlife activity, when those activities impact either water quality or the integrity of watershed structures or resources, then the Division must take an active role in mitigating those damages. The species of concern on the Ware River watershed and their associated risks are:

- Beaver - can cause damage to watershed structures and property; can negatively impact water quality depending on their location and site conditions
- White-tailed deer - can alter tree species diversity and abundance
- Moose - can alter tree species diversity and abundance

7 Management to Protect the Natural Landscape on DCR Property

Contents: The source of the Division's mandate to protect biodiversity during its management of the Ware River watershed properties and Division goals for meeting that mandate. Rare natural communities, rare fauna, and rare flora on the watershed are described, as well as the threats imposed by invasive species and management approaches for dealing with these threats.

Key Points:

The DCR/DWSP's goals for biodiversity focus on either maintaining or enhancing natural ecosystems across the watershed. The DCR/DWSP recognizes that its greatest contribution to regional biodiversity is protecting large areas of land from development and maintaining most of those lands in forest cover.

The DCR/DWSP's principal goals for maintaining biodiversity are to retain most of these lands in forested condition, to identify and provide habitat for the protection of uncommon and rare flora and fauna, to eliminate and prevent the spread of non-native invasive species, and to provide the range of seral stages from early successional habitat through unmanaged mature forest.

8 Management to Protect Cultural Resources on DCR Property

Contents: Policy with regard to cultural resources and methods for the protection of cultural resources during management activities.

Key Points:

Preservation legislation and DCR's Cultural Resource Management program are designed to ensure that future generations will have the opportunity to understand, appreciate, and learn about the past. DCR seeks to identify and preserve cultural sites and resources on DCR watershed lands.

9 Research, Inventory, and Monitoring Needs

Contents: Research needs in the general areas of forest, wildlife, and cultural resources.

Key Points:

Ten specific research projects have been identified by DCR staff as necessary to improve management efforts on the Ware River watershed.

10 Appendix I: Discussion of Forest Management Approaches

Contents: A detailed literature review on the relationship between various forest management approaches and water yield and quality.

11 Appendix II: Uncommon Plants Potentially Occurring on DCR Properties and Habitats in Which Rare Plant Species are Likely to be Found (Searcy, 1996)

Contents: A copy of portions of a consulting botanist's 1996 report on rare plant occurrences on DCR/DWSP forests.

12 Literature Cited and General References

Contents: The bibliography for this plan includes all literature cited within the body of the plan, as well as other general references that may be of interest to readers.

13 Glossary of Terms

Contents: Terms and definitions used by the DCR throughout the plan are listed alphabetically, with sources included where necessary.

1 Introduction, Mandates, and Statement of Mission

1.1 2003 Reorganization of State Agencies and Effects on this Plan

A major change has taken place in the Executive Office of Environmental Affairs during the preparation of this document for public review. On June 30, 2003, Governor Mitt Romney signed legislation that merged the Metropolitan District Commission (MDC) and the Department of Environmental Management (DEM) into the new Department of Conservation and Recreation (DCR). Within the new Department of Conservation and Recreation are three Divisions: the Division of Urban Parks and Recreation (DUPR), the Division of State Parks and Recreation (DSPR), and the Division of Water Supply Protection (DWSP, formerly the MDC/Division of Watershed Management).

While the agency adjusts to structural changes, our mission remains unchanged. Like the former MDC/Division of Watershed Management, the DCR/Division of Water Supply Protection manages and protects the drinking water supply watersheds for 2.2 million residents of Massachusetts. The Ware River watershed, Quabbin Reservoir watershed, and Wachusett Reservoir watershed are the sources of drinking water for distribution by the Massachusetts Water Resources Authority (MWRA).

Throughout this final draft of the Ware River Land Management Plan, we have attempted to make appropriate changes in terminology. In some contexts, particularly in historical discussions, the term "Metropolitan District Commission/Division of Watershed Management" or simply MDC or MDC/DWM remain accurate (e.g.,"MDC developed land acquisition models in 1998 for the Ware River"). In many instances, DWM or MDC were simply replaced with "the Division" to try to avoid confusion. Readers should be aware that in the context of this plan, "the Division" always refers to the Division of Water Supply Protection or the former Division of Watershed Management, not to any other Division in the Commonwealth. Along these lines, the frequently-used term "Division lands" refers to properties that are owned by the Commonwealth but are under the care and control of the Division of Water Supply Protection.

1.2 Agency Mission and Mandates

The Department of Conservation and Recreation, Division of Water Supply Protection (DCR/DWSP) and the Massachusetts Water Resources Authority (MWRA) supply drinking water to 47 Massachusetts communities, most of which are in the metropolitan Boston area. The DCR/DWSP is responsible for collection and storage of water, protection of water quality, and management of the watersheds (Quabbin Reservoir, Ware River, Wachusett Reservoir and Sudbury Reservoir – Figure 1). The Division was established in 1984 when the state legislature divided the former MDC Water Division into the new Division of Watershed Management (DWM), responsible for watershed operations and management, and the Massachusetts Water Resources Agency (MWRA), responsible for water distribution and treatment. As noted above, the MDC/DWM became the DCR/DWSP on June 30, 2003.

The DCR is a multi-faceted state agency within the Executive Office of Environmental Affairs, responsible for reservations, parks and recreational facilities, parkways, and drinking water supply watersheds. Chapter 372 of the Acts of 1984 established the MDC/DWM and provided its primary mandate. Among other things, this act directed the Division to "…utilize and conserve…water and other natural resources in order to protect, preserve and enhance the environment of the Commonwealth and to assure availability of pure water for future generations." In addition, the DWM was directed to periodically prepare watershed management plans to provide for "…forestry, water yield enhancement and recreational activities."

In order to meet the above legislative mandates, the Division established programs in Environmental Quality, Engineering and Construction, Watershed Operations, Public Education, and Natural Resources, all tasked primarily to the protection of this drinking water supply. The long-term goals of the Division are to:

- Ensure availability of clean water for present and future generations.
- Effectively manage, protect, conserve and enhance the natural and structural resources under the responsibility of the DWSP to ensure public health and safety.
- Prevent adverse environmental impacts that could degrade watershed resources.
- Provide educational programs in order to protect watershed resources.
- Conduct research that guides and assists the effective management of watershed resources.
- Develop emergency contingency plans that address existing and potential threats to DWSP resources.

1.3 Plan Overview and Relationship to Other DCR/DWSP Planning

The DCR/DWSP's primary purpose is the long term production and protection of high quality drinking water. The Division prepares and regularly updates a variety of plans to meet this purpose. In addition to Land Management Plans, these include Watershed Protection Plans and Public Access Management Plans. The first Watershed Protection Plan for the Ware River was completed in 1991 as a component of the MWRA Drinking Water Quality Improvement Strategy. This plan was most recently updated for the Ware River in December 2000, and amongst other summaries identifies recreation and unauthorized activities as moderate threats to drinking water supply. The Public Access Management Plans are prepared to address these threats. The most recent Access Plan for the Ware River was completed in January 2000, laying out area and activity restrictions for approximately 30 different recreational uses demanded by the public.

Land Management Plans for DCR/DWSP properties have been written and updated since 1961, when the first "plan" for Quabbin's forests was written in the form of a master's thesis by Fred Hunt, Forest and Park Supervisor. These plans were initially focused forestry and wildlife management plans, but have evolved to more comprehensive plans that now also include land acquisition, cultural resources protection, and the management of biodiversity. The first forest and wildlife management plan for the Division properties on the Ware River was written in 1983 by Stephen Drawbridge, the Division's Ware River Forester.

The 2003-2012 Ware River Land Management Plan is the first comprehensive plan for natural resources on the Ware River watershed. This land management plan proposes methods to effectively manage, protect, and conserve the natural resources on Division watershed properties, with the principal objective of enhancing the protection of the water supply. Developing a management strategy to meet all the needs assigned to the DCR/DWSP is a complicated task. There are numerous constraints that must be considered in developing management options. Effective management requires an ongoing process of reviewing and weighing uses against potential impacts upon the primary goal of water quality protection. This review is followed by carefully crafting policy and management decisions that consider the public's desire to use and enjoy the area, while preserving the primary objective of water supply protection.

The plan outlines DCR/DWSP's management objectives to maintain the most effective, practical, and ecologically sustainable watershed land cover in order to maximize the natural filtering capability of the Division watershed lands surrounding the Ware River intake. The plan also identifies management strategies for land acquisition, wildlife, cultural resources and biodiversity.

The Ware River Watershed Land Management Plan calls for the development and maintenance of a diverse, multi-layered forest cover on much of the watershed, similar to the Quabbin and Wachusett Land Management Plans. This plan primarily focuses on management over the next ten years, but it also considers the forest cover and watershed conditions 60 years in the future. The importance of this long range view is that it plans for a land/forest filter that should continue to function effectively in the face of such events as hurricanes, floods, fires, insect and disease outbreaks, environmental pollution, and other impacts that may be unpredictable to managers today. The Division believes that maintaining a forest cover that is diverse in age classes and species composition represents a conservative strategy for addressing this uncertainty.

The plan's sections include: 1) Introduction, Mandates, and Statement of Mission; 2) Background: Ware River Watershed; 3) Water Resources; 4) Land Protection; 5) Management of Forested Lands Controlled by the Division; 6) Wildlife Management; 7) Management to Protect the Natural Landscape on Division Property; 8) Management to Protect Cultural Resources on Division Property; and 9) Research, Inventory, and Monitoring Needs. The plan is written so that the management components are based on principles outlined in sections that precede them. The Division's intent is for this plan, when implemented, to achieve drinking water protection while also allowing controlled public use of some drinking water supply lands.

1.4 Land Management Planning

1.4.1 Public Input to DCR/DWSP's Land Management Plans

Public input is an important component in the effective management of DCR/DWSP properties. As managers of public land, DCR/DWSP staff has a responsibility to solicit public input in order to address concerns, explain existing management practices, and integrate new ideas, when practical, in order to provide the best possible protection for the drinking water supply. The goals of the Division's public input process for land management on all watersheds are to:

- Regularly solicit public input in order to better understand the broad range of current public issues and concerns regarding forest and wildlife management, so that the Division can better integrate these concerns into protection strategies and the development of goals and objectives for maintaining watershed integrity.

- Educate the public regarding the goals and objectives of the Division with regard to its watershed management program.

- Improve the understanding of both agency staff and the public regarding the technical aspects of forest and wildlife management on the Division's watersheds.

- Work to educate the public regarding strategies for the implementation of the land management program, in order to address concerns and retain public confidence in these strategies.

1.4.2 Regular Revisions to the Ware River Land Management Plan

Progress on implementation of the Ware River Land Management Plan will be presented as a component of an annual public meeting. As a component of this meeting, Forestry and Natural Resources staff will review forest and wildlife management activities, land acquisition progress, and a variety of related research and policy developments.

The plan is written as an DCR/DWSP guidance document for land management activities, and will also serve as a tool for involving the public in the development of land management objectives and strategies. This plan should be viewed as an *adaptive watershed management plan*, to be applied but updated and modified as new properties are added and new information comes to light.

1.4.3 Scientific and Technical Review

Shortly following the writing of the 1995-2004 land management plan for Division properties on the Quabbin Reservoir watershed, the Division organized the first meeting of the Quabbin Science and Technical Advisory Committee (QSTAC). This committee was assembled in an effort to bring Division staff together with professionals in related fields to provide discussion and advice on the technical aspects of watershed management. The committee includes approximately 30 professionals from colleges and organizations throughout the northeast, is co-chaired by a scientist and a Division staff member, and has met with Division resource managers more or less annually since 1996.

Although assembled to address issues arising from management at Quabbin, the QSTAC has discussed issues of broad importance across all Division properties. The writing of this Ware River Watershed Land Management Plan has benefited from past QSTAC discussions where topics have included: optimizing opening sizes for forest regeneration and water protection; management recommendations for areas with special management restrictions (islands, wetlands, steep slopes, designated natural areas); strategies to respond to the effects of the hemlock woolly adelgid; protocol for the release of biocontrol agents (e.g., an imported beetle proposed for release to control the hemlock woolly adelgid); and recommendations for the management of "historical woodlots" (areas on the watersheds that have been managed, but have always been forested).

It is the Division's intention to continue to meet periodically with this advisory group to explore scientific and technical issues of land management that arise in the implementation of this and other DCR/DWSP land management plans.

FIGURE 1: ACTIVE DWSP WATERSHEDS - BASE MAP

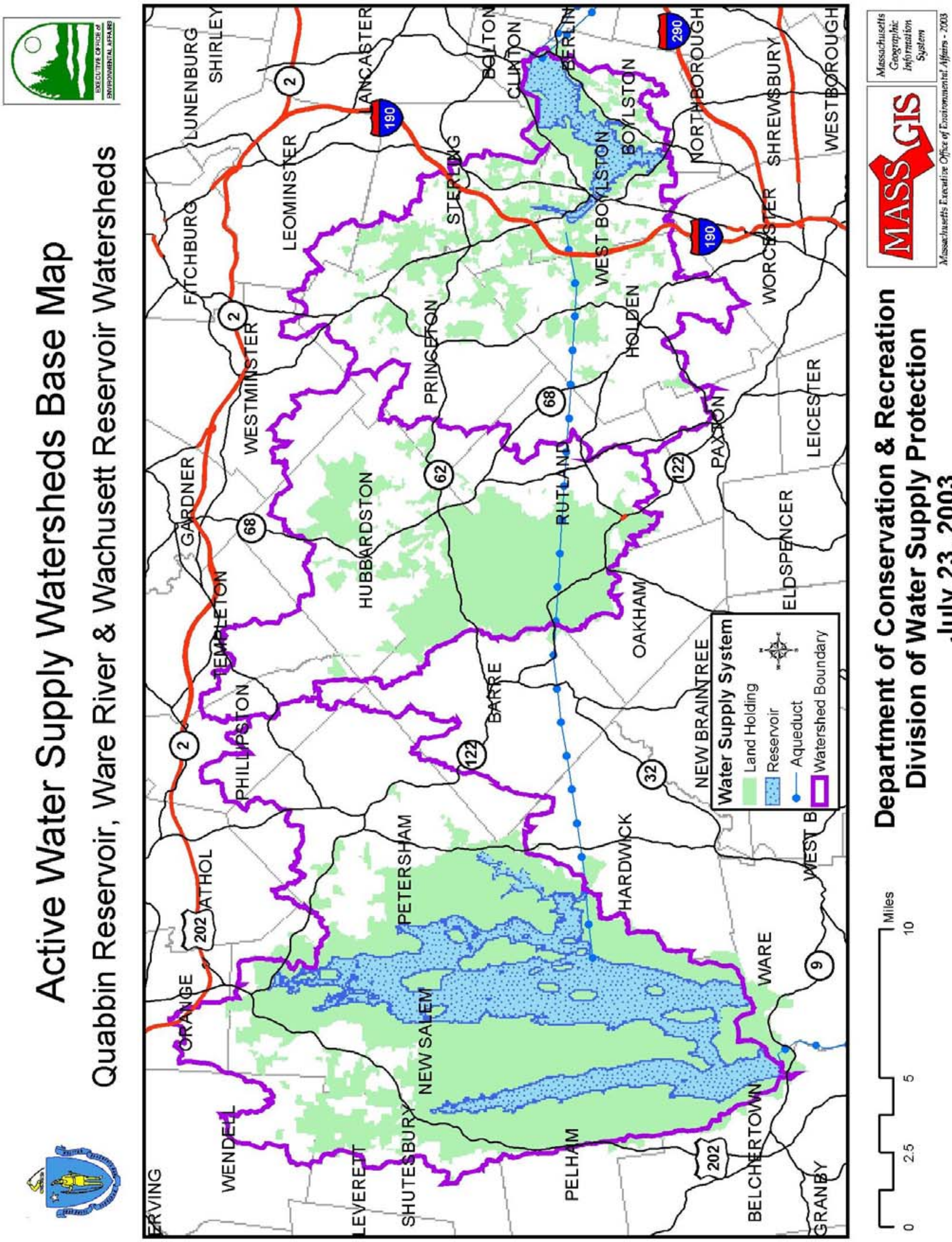
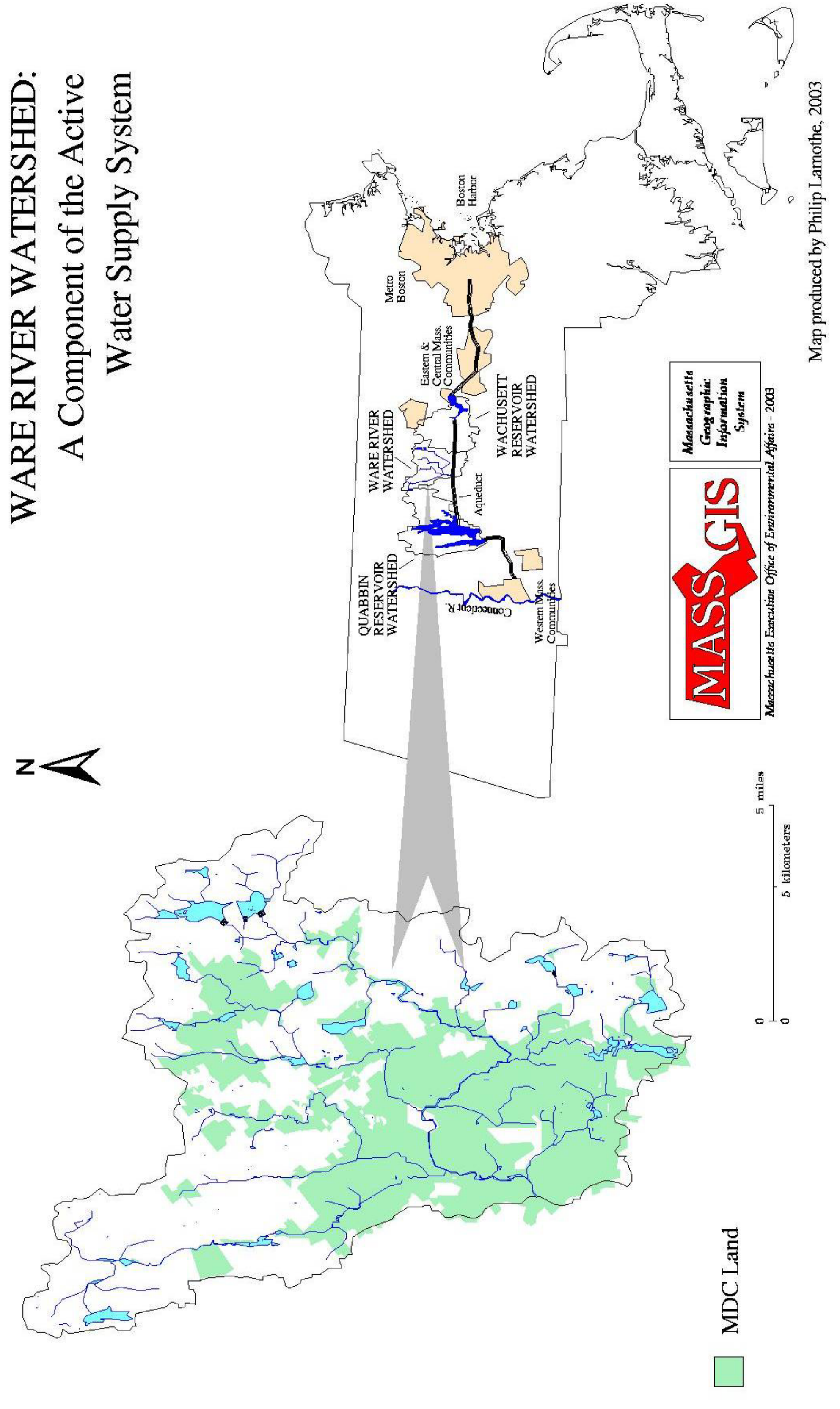


FIGURE 2: WARE RIVER WATERSHED AND SYSTEM MAP



2 Ware River Watershed Background

2.1 Physical Characteristics

2.1.1 Location and Topography

The Ware River Watershed lies in the Central Uplands in North Central Massachusetts (see Figure 2). It is characterized by rolling hills separated by broad river valleys, and is contained within the Worcester Plateau and the Lower Worcester Plateau EPA ecoregions. For the purposes of this land management plan, the watershed of interest is above the Intake Works at Shaft #8**.** The watershed above this intake covers 96.8 square miles, or 61,952 acres. It encompasses parts of eight towns: Barre, Hubbardston, Oakham, Phillipston, Princeton, Rutland, Templeton and Westminster. The highest elevation, at 1,720 feet above sea level, is near the summit of Mount Wachusett on the northeast edge of the watershed. The lowest elevation, at 650 feet above sea level, is at Shaft #8, located on the extreme southwestern edge, for a difference in elevation of 1,070 feet.

The Division of Water Supply Protection currently controls 23,694 acres in the Ware River watershed and holds 11 Conservation Restrictions (CRs) on an additional 787 acres. There are few areas of steep (>35%) slopes on Division lands. Harding Hill and Oak Hill are the most prominent points of relief. Two prominent ridges extend through the property. The Oakham Ridge runs east-west and defines the southern edge of the watershed, and the Burnshirt Ridge runs north-south between the Burnshirt River and Canesto Brook valleys.

2.1.2 Geology

The following information is adapted from a report by David Ashenden, former MDC Geologist.

2.1.2.1 Bedrock Geology

Bedrock of the Ware River watershed consists of high-grade complexly folded metamorphic rock heavily intruded by pegmatite. The bedrock is separated into three formations:

1. The Partridge Formation is the oldest, consisting mostly of rusty weathering schist. It is of Middle Orodovician age (450-470 million years ago).

2. The Paxton Formation is younger then the Partridge, being of presumed Silurian age (400-440 million years). The Paxton consists largely of gray granulite splitting into thin layers. It also contains a separately mapped white sulfidic schist member which contains basal quartzites.

3. The Littleton Formation is composed mostly of gray graphitic schist and is the youngest formation of the area, being lower Devonian (upper 300s to 400 million years in age).

The pegmatite is like very coarse-grained granite and has largely replaced the original rock of the three formations listed above, leaving only small amounts of the original rock but in sufficient quantity to show its former distribution. Very minor basalt was intruded during the Late Triassic to Early Jurassic, a time on the order of 180 million years ago.

The Acadian orogeny that immediately followed the deposition of the Littleton Formation left the rocks of the area with a very complexly folded structure. In the Ware River Watershed the structure appears deceptively simple as the Oakham anticline; a broad arching of the rocks on the east side of the area dip to the east and those on the west side of the area dip to the west. The Oakham anticline is, however, but one element superimposed on a more complex regional structure.

2.1.2.2 Glacial Geology

Exposure of the bedrock is limited because it is veneered by glacial drift consisting of till and outwash. In the past million years or so the area has been subjected to multiple continental ice sheets. The most recent of these melted back only about 10,000 years ago leaving most of the area covered by glacial till. There are numerous drumlins, which are mounds of glacial till ranging from a few tens of feet to more than one hundred feet in height, forming ellipsoidal hills elongated in the direction of ice flow.

Glacial meltwater left a series of extensive sand and gravel outwash deposits in most of the valleys. As the ice melted back, the meltwater followed a variety of routes, exposing newer and lower avenues of escape and leaving a series of independent but related outwash deposits. Meltwater first escaped southward through Dean Pond and the Fivemile River valley and also through Long Pond and the Sevenmile River valley. In addition, another early escape route passed southward toward Dean Pond, passing west of the present Muddy Pond and west of the drumlin at the southern limit of the Division's holdings.

As the ice retreated further northward, meltwater drainage entered a second stage. The early route to the west of Muddy Pond and the drumlin was replaced by the central route directly to Dean Pond. The southern end of Long Pond was blocked by glacial debris, and meltwater found a lower route of escape from the north end of Long Pond by a channel to Dean Pond. This channel, now dry, is still a conspicuous feature on the landscape. As the ice retreated northward during this stage, a large outwash plain, the Pine Plains outwash plain, was deposited. The bedrock surface slopes to the north but drainage down the Ware River valley was still blocked by ice. Outwash of sand and some gravel graded from the north to the south filled the depression. Deposits to the north are in excess of one hundred feet thick. Muddy Pond and the Parkers Brook valley were occupied by masses of residual ice which may have been totally buried. Subsequent melting of the ice after meltwater ceased to pass this way left the depression which is now Muddy Pond and the valley occupied by Parkers Brook, in the outwash.

A third stage of meltwater routing and outwash deposition was initiated when the ice melted back sufficiently to expose the present Ware River valley at Shaft 8. Meltwater then followed the lower route of the Ware River and ceased to escape via Dean Pond and the Fivemile River. Deposition of the Pine Plains outwash plain ceased abruptly so that today the sand terminates northward near Shaft 7 and the southern limit of Blood Swamp. Drainage from the Longmeadow Brook area was still blocked to the north by ice. Drainage therefore continued to flow south to the Long Pond area and through the channel to the west but now used a route through the Muddy Pond area and down the Parkers Brook valley. This water passed through the residual ice masses of the Parkers Brook valley, creating the esker deposits there. With continued ice front retreat during this stage, the outwash deposits of the Ware River valley north of Coldbrook formed. These deposits consist of a series of kames and eskers deposited respectively around and within the residual ice masses. The Blood Swamp and Stevens Branch Swamp areas have only minor outwash deposits. This may be due to a combination of residual ice, which left no room for outwash deposits and the apparent absence of major meltwater streams directed this way.

The fourth stage of meltwater routing occurred with the opening of the Ware River gorge below the Barre Falls Flood Control Dam. The present drainage of the area was now more or less established.

The exact details of the shift of the East Branch and the Longmeadow Brook drainage to its present course remain uncertain. There appear to have been several possible routings westward toward Blood Swamp and the more northern swamp east of Harding Hill while the East Branch narrows north of Prison Camp location remained plugged with ice. Gradually, with the melting of that ice plug, the East Branch opened and the drainage was able to follow its present route. Outwash in this section is minimal, and portions of the East Branch flow on till.

With further retreat of the ice front northward, the development of the drainage and outwash deposits was essentially a matter of outwash deposition around stagnant residual ice masses in the Burnshirt River, Canesto Brook and West Branch valleys, forming kame terraces, knob and kettle terrain, and eskers. There are minor and local complications but these will not be detailed in this summary. Gradually the ice melted out of the Ware River watershed, and with the opening of the Millers River valley to the north, meltwater ceased to flow this way and outwash deposition was complete.

2.1.3 Soils

Soils for other DCR/DWSP watersheds have been mapped by federal agencies, but the Ware River watershed area is still without a complete survey. A draft survey is under review and the final form will be incorporated into management planning for the Ware River watershed as soon as it becomes available. For the purpose of watershed management, the Ware River soils will be grouped and mapped into five classes, based upon the soil depth and drainage characteristics.

1. Excessively drained soils are usually very coarse textured, stony, and deep. Water is removed from these soils very rapidly. These soils are thick loamy sands occurring primarily on glacial outwash. These are relatively deep soils (>65") and occupy the dry portions of the river valleys.

2. Well drained thin soils are commonly of medium texture. Water is removed from the soil fairly rapidly, but is available to plants during most of the growing season. The principle soils occurring in this class are shallow soils (1-24") formed in glacial till located on the sides of hills and valleys.

3. Well drained thick soils (24-65") are formed in loamy and sandy glacial till on uplands.

4. Moderately well drained soils are wet for only a short period during the growing season but the removal of water is somewhat slow during these times. These soils consist of very deep (to 65" and greater) fine sandy loams.

5. Poorly to very poorly drained soils usually result from a high water table, where water is removed so slowly that the soil is saturated or remains wet for long periods during the growing season. These soils are very deep, extending to a depth of 50" or more, and consist of fine sandy loams and mucks.

2.1.4 Hydrology

Precipitation on the Ware River watershed is fairly well distributed throughout the year. The average annual precipitation recorded since 1931 has been 43.25 inches or approximately 73 billion gallons received annually over the entire watershed. The average annual stream flow for this period recorded at Shaft #8 and the weir below has been 39.3 billion gallons, or 53% of the average annual precipitation (MDC/MWRA records).

The Ware River at the Intake Works is a 4th order stream formed by the convergence of seven major tributaries. These are the Burnshirt River (2nd order), the Canesto Brook (3rd order), Natty Pond Brook (2nd order), Longmeadow Brook (2nd order), Parkers Brook (2nd order), and the East and West Branches of the Ware River (3rd and 2nd order respectively). Most of the tributaries are warm water streams with low gradients, although there are segments of each where the gradients increase. Stream channel characteristics vary from entrenched to unconfined, but the greatest percentage is in the latter category. The channel pattern ranges from regular to tortuous meandering. In total, these tributaries travel about 77 miles to the Intake Works. The general drainage pattern is from northeast to southwest, although there are some major deviations that are the result of the last glaciation. There are sixteen large ponds scattered over the watershed, ranging in size from about 30 acres to over 100 acres. The Division controls the entire shoreline on four of these and part of the shoreline on an additional five. Two of the remaining seven ponds are maintained by the City of Fitchburg as a drinking water supply. The remaining five are privately owned and are developed to varying degrees.

Wetlands are a major part of this hydrologic system, accounting for more than 3,500 acres on Division lands on the Ware River watershed. They include coniferous and deciduous wetlands as well as those dominated by shrub and herbaceous cover. Over the past decade, a number of these have shifted from forested wetlands to shrub and open wetlands, as a direct result of an increase in beaver activity.

Wetland Expanded by Beaver

2.2 Paleoenvironments

(Note: this section is quoted from the September 1990 report on cultural resources prepared for the MDC / DWM by the Cultural Resource Group of Louis Berger & Associates, Inc. It is included here for general information on post-glacial development of the landscape, and to provide a context for prehistoric cultural resources protection)

"Prior to prehistoric man's entry into central Massachusetts, glaciers had scoured the landscape. Glacial Lake Nashua occupied the approximate position of the Wachusett Reservoir and another, Lake

Hitchcock, was located from 10 to 15 miles west of Quabbin. The lakes were apparently gone or recently drained as prehistoric Native Americans began to populate the area.

Forests of this early time are characterized as spruce parkland and spruce woodland with admixtures of some deciduous elements creating a species mosaic that has no modern analog (Curran and Dincauze 1977). Excessively drained glacial landforms would have been attractive to both man and animal during this time of cooler and wetter climate. The biological carrying capacity of area forests would have been less than that of modern habitats in the same area but greater than what can be ascribed to modern conifer-dominated forests.

Bogs, marshes, and ponds probably characterized many lowland environments as they do today. The effects of beaver populations on these lowland environments during prehistoric times cannot be accurately evaluated. Beaver are responsible for many of the modern wetland features. The types of vegetation associated with them, however, would have been substantially different. Nonetheless, we can assume that these features would have been game-attracting habitats. Extinct and more northern-adapted animal species would have existed in the area including mastodon and caribou. Now-extinct drainage patterns were probably viable low order streams. The velocity of streams in general was probably great as they handled glacial meltwater.

As regional climates began warming circa 8,000 BC, the spruce woodland was eventually replaced by a conifer-deciduous forest in which pine was heavily represented (Dincauze and Mulholland 1977). No dramatic changes in the biological carrying capacity of the project region are postulated although northern animal species were likely being supplanted by species more common to the area today. Streams were undoubtedly prolific, even in comparison with the well-watered settings of the present time.

Climates circa 6,000 BC and 1,000 BC are viewed as radically oscillating with warm temperatures and decreased rainfall being the overall trend. Windblown soils found in Central Massachusetts and the Middle Connecticut River Valley (Johnson and Stachiw 1985; Johnson and Mahlstedt 1984; Dincauze et al., 1976) may be an indirect result of this period referred to as the Thermal Maximum. Pine-oak forests give way by 4,000 BC to a temperate deciduous forest characterized by oak and hemlock. These new plant communities, together with adapted animal species, would have dramatically increased the carrying capacity of local environments and the range and density of resources that could be exploited by humans. Although many upland and low order streams may have become intermittent or extinct at this time, the quality of upland and lowland environments was dramatically increased. Seasonal changes were probably first pronounced during this period in terms of the fluctuating productivity of biological resources exploited by man. At the same time, decreasing rates of sea level rise would have helped to stabilize anadromous fish populations and regularize their appearance in local areas. Climatic shifts circa 1,000 BC and later are viewed as minor and resulted in no major alterations of regional environments. The quality of environments in Division watershed areas was essentially modern by 1,000 BC if not earlier."

2.3 Regional Land Use History

2.3.1 Prior to European Settlement

In order to understand the present forest and to predict what may occur in the future, it is essential to look at the forces that shaped the forest in the past. The primeval forest of Central Massachusetts consisted of both deciduous and coniferous species. The area lies within the Transition Zone between the Northern Hardwood Forest characterized by beech, sugar maple and birch, and the Central Hardwood Forest composed of oak, chestnut (formerly), and red maple. White pine, pitch pine and hemlock were also present in this primeval forest. White pine made up the main component of stands on well-drained sites, while hemlock occurred in association with hardwoods on the poorly-drained soils.

Natural disturbance plays a major role in any forest development. In New England, hurricanes and fire have been the two most influential natural disturbances following the last glaciation and both have influenced forest development before and after European settlement. Human land use has been a considerable, often complex, form of disturbance. Little is known definitively about the specific impact of Native American land use on the Central Massachusetts forest, but the arrival of European settlers brought new land use practices never before seen on this landscape.

2.3.2 Colonial Settlement

In 1686, an area called "Naquag" was purchased from the Native Americans for twenty three pounds sterling by Lancaster residents Henry Willard, Joseph Foster, Benjamin Willard and Cyprian Stevens. This area consisted of 93,160 acres and contained the present towns of Rutland, Oakham, Barre, Hubbardston, and parts of Princeton and Paxton. The entire present Division holdings were originally part of this purchase. In 1713, the proprietors petitioned the General Court for confirmation of their deed. It was granted the following year with the stipulation that within seven years, sixty families be settled on the property. Lots were surveyed in Rutland, and within two years permanent homes were built. Over the next three decades, the towns of Oakham, Barre, and Hubbardston were settled. All four communities were situated on hilltops surrounding the Upper Ware River Valley. The natural meadows along Longmeadow Brook in Pine Plains and along the Ware River were held as common land for grazing, while land closer to the settlements was being cleared. The abundance of high quality timber in close proximity to streams with the capacity to generate power attracted the settlers into the forest. According to historic records, the Pine Plains area contained vast quantities of high quality white pine and pitch pine favored in building. Sawmills and gristmills were built along several streams, and primitive roads were constructed to move materials to and from the Valley. Only the largest and best quality trees were removed. These products were for local use and served only the few settlements that rimmed the valley.

In the late 18th century, settlement of the valley began in earnest. The forest was cleared on the bottom lands. The completion of the Massachusetts highway connecting Northampton and Worcester simplified the transport of goods. The agricultural operations grew in number and size, and the forest area was reduced.

During the first half of the 19th century, an estimated seventy percent of Central Massachusetts land was in agricultural use. The remaining forests were used for lumber and for fuelwood. The best quality trees were removed for building and the small trees for fuelwood. During this period, practically all the land was altered in some way by human land use.

In 1815 and 1821, minor hurricanes swept through the area, leveling portions of the remaining forested lands. Hemlock was a major component of these mixed stands because the pine and hardwood had been removed. Following the disturbance events, hemlock seedlings and hardwood sprouts were released and perpetuated the existing type.

2.3.3 Land Abandonment

A decline in agriculture started about 1840 and continued until the turn of the century. The completion of the Erie Canal and the expansion of the railroads into the rich farmlands of the Midwest, as well as the growth of industry and the discovery of gold in California, drew farmers from rocky New England soil.

The Upper Ware River Valley was no exception. Many farms were abandoned, while other farming operations ceased when the owners found work in the industrial communities growing in the valley. The availability of water power made the valley attractive to industry. The completion of the Central Massachusetts Railroad and Ware River Branch of the Penn Central Railroad in the 1870s facilitated the procurement of raw materials and the distribution of products over a large area. In 1872, William Stearns purchased a mill in West Rutland to manufacture bed comforters and cotton batting. By 1900, the company employed one hundred people. New Boston in North Rutland was the site of the Moulton Brothers shoddy mill (shoddy was a lower-quality material woven from reclaimed wool). A gristmill and sawmill were situated in Coldbrook, on the western side of the watershed. All these industrial communities were still in operation in the late 1920s when the Commonwealth purchased the area for drinking water supply protection.

The forest moved quickly to reclaim abandoned farm lands. The sod and grasslands of open fields furnished an ideal seed bed for white pine which rapidly established itself. Some scattered hardwoods were intermingled, such as oak, chestnut, red maple, and gray birch, but few were able to compete in the thick stands of white pine. As these stands matured and the canopies rose, increased understory light favored the seedling establishment of shade tolerant hardwoods, such as oak and chestnut. By the turn of the century, the commercial value of the second-growth, old-field pine stands became evident to many, even though the quality of these stands was vastly inferior to the old growth pine. Industries based on the use of the inferior quality pine grew up all over Worcester County. Box shops, pail, match, heel and woodenware factories utilized millions of board feet.

Many old-field stands within the Ware River watershed were removed during this period. Their density made clear-cutting the most practical means of harvesting. All trees of sufficient size with some value as lumber were removed. These operations released the understory hardwoods. Some of the light seeded hardwoods were also present, such as gray birch and poplar, but as the stands matured these "pioneer" species succumbed to competition. On the moist poorly drained sites, American chestnut and red and scarlet oak predominated. These species grew well and formed high quality stands. On dry sites black oak, white oak, and some red oak formed the major component of slow-growing, low-quality stands. As a result of the heavy slash left from logging, fire destroyed many young hardwood stands. Where the fires were not particularly hot, the hardwoods resprouted and continued to develop. Where the organic matter was severely burned, however, stand composition changed. White pine and mixtures of low quality hardwoods became reestablished. Such stands have developed slowly, and only the pine component has economic value. The Cunningham property in North Hubbardston is an example of this condition.

In 1903, another disturbance event occurred, which changed the species composition of many of the hardwood stands. The chestnut blight was introduced into this country, and within two decades had eliminated the chestnut as an important element of the New England forest. This was a severe blow to the economy. Chestnut is extremely durable and easy to work and was favored as both lumber and fuelwood. On most sites it outgrew oak. With the loss of chestnut, oaks became the dominant species in hardwood stands.

2.4 Present Status of Ware River Forests

The Ware River watershed is part of the Worcester hills ecoregion, an area with a wide range of glacial influences. There is an abundance of outwash soils, tills in drumlins, washed tills, and tills of varying degrees of drainage, all are of varying depth. The glacial outwash clogged many drainages creating abundant wetlands. This region once supported a forest dominated by the long-lived oak, chestnut, pine, and hemlock. The moist tills also supported pockets of northern hardwoods. Most of the original forest was cleared for agricultural purposes, such as pasture or crop land. As mentioned previously, most of this agricultural land had been abandoned by the turn of the century, resulting in a steady conversion from open agricultural habitat to forest cover. In the past 20-30 years this region has experienced significant population growth and consequently continues to be subdivided and developed for residential and commercial use. As a result, average private ownership parcel size has shrunk. Presently, approximately 70% of this region is covered by forest. There has been a gradual shift in forest composition as well; the amount of oak and pine has decreased and the amount of red maple, hemlock and black birch has increased. Red maple has become the most common tree in Massachusetts, taking over from white pine, according to statewide surveys. Black birch and hemlock have made the greatest gains in abundance due to private land cutting practices that have consistently harvested the more valuable pines and oaks.

The forest that presently covers most of the Division holdings at the Ware River resulted from: 1) natural succession following agricultural abandonment, 2) heavy cutting (mostly white pine) 60-100 years ago and 3) Division forest management activities over the past 30 years. It is the product of the interplay of environmental and social factors over time. The Industrial Revolution, agricultural abandonment, railroad construction and land takings for metropolitan Boston's water supply are some of the social factors that have influenced forest composition, against a backdrop of environmental factors that have included the hurricane of 1938, the chestnut blight, and Dutch elm disease. This legacy of both social and environmental factors is apparent in the forest as it exists today.

2.5 Ware River Flora

As part of an ongoing effort to address the biological diversity within its watersheds, the Division continues to gather records of present species. During 1995 and 1996, MDC contracted with the University of Massachusetts Herbarium to inventory proposed timber harvesting areas on the Quabbin and Ware River watersheds in search of rare plant species. The herbarium staff also compiled a flora, a list of all plant species encountered. This Ware River flora is included in Table 1.

Epigaea repens, *Trailing arbutus. MA state flower.*

TABLE 1: PLANT SPECIES OCCURRING ON THE WARE RIVER WATERSHED

Field List – Flora
1996 Survey of Proposed Harvesting Lots
Karen Searcy - U Mass Herbarium
rare species underlined and bold;
*invasive species

Dicots

Acer pensylvanicum	Striped maple
Acer rubrum	Red maple
Acer saccharum	Sugar maple
Achillea millefolium	Common yarrow
Actaea pachypoda	Doll's eyes
Actaea rubra	Red baneberry
Actaea sp.	Baneberry
Amelanchier sp.	Shadbush
Amelanchier (canadensis?)	Swamp shadbush
Amelanchier bartramiana	Bartram's shadbush
Amphicarpaea bracteata	Hog peanut
Anemone quinquefolia	Wood anemone
Apocynum androsaemifolium	Spreading dogbane
Apocynum sp.	Dogbane
Aquilegia Canadensis	Wild columbine
Aralia nudicaulis	Wild sarsaparilla
Aronia arbutifolia	Cherry
Aronia melanocarpa	Choke cherry
Asclepius sp.	Milkweed
Asclepius syriaca	Common milkweed
Aster acuminatus	Whorled aster
Aster divaricatus	White wood aster
Baptisia tinctorea	False indigo
**Berberis thunbergii*	Japanese barberry
**Berberis vulgaris*	Common barberry
Betula alleghaniensis	Yellow birch
Betula lenta	Black birch
Betula papyrifera	White birch
Betula populifolia	Gray birch
Carpinus caroliniana	Iron wood
Carya sp.	Hickory
Castanea dentata	Chestnut
Chamaedaphne calyculata	Leather-leaf
Chimaphila maculata	Spotted wintergreen
Chimaphila umbellata	Pipsissewa
Chrysosplenium americanum	Golden saxifrage
Circaea alpine	Enchanters nightshade
Circaea lutetiana var. canadensis	Canadian nightshade
Clematis virginiana	Virgin's bower
Comandra umbellata	Umbellate toadflax
Comptonia peregrine	Sweet fern
Convolvulus sp.	Bindweed
Coptis trifolia	Goldthread
Cornus alternifolia	Alternate-leaf dogwood
Cornus amomum	Silky dogwood
Cornus canadensis	Bunch berry
Cornus racemosa	Red panicle dogwood
Cornus sp.	Dogwood
Corydalis sempervirens	Pale corydalis
Corylus americana	American hazelnut
Corylus cornuta	Beaked hazelnut
Crataegus sp.	Hawthorn
Dalibarda repens	Robin-run-away
Diervilla lonicera	Bush honeysuckle
Drossera rotundifolia	Round-leafed sundew
Epigaea repens	Trailing arbutus
Euonymus alatus	Winged spindle-tree
Fagus grandifolia	Beech
Fragaria sp	Strawberry
Fragaria virginiana.	Common strawberry
Fraxinus americana	White ash
Fraxinus pennsylvanica	Green ash
Fraxinus sp.	Ash
Galium sp.	Bedstraw
Galium trifidum	Three-cleft bedstraw
Gaultheria procumbens	Wintergreen
Gaylussacia baccata	Black huckleberry
Gaylussacia sp.	Huckleberry
Geranium maculatum	Wild geranium
Glechoma hederacea	Ground ivy
Hamamelis virginiana	Witch hazel
Hemerocallis sp.	Day-lily
Hepatica sp.	Liverleaf
Hedyotis caerula	Bluets
Hydrocotyle americana	Water-pennywort
Hypericum sp.	St. John's wort
Ilex verticillata	Winterberry
Impatiens capensis	Jewelweed
Kalmia angustifolia	Sheep laurel
Kalmia latifolia	Mountain laurel
Leonurus cardiaca	Common motherwort
Lespedeza sp.	Bush-clover
Lindera benzoin	Spicebush

*Lonicera sp.	Honeysuckle
*Lonicera tatarica	Tartarian honeysuckle
Lycopus uniflorus	Northern bugleweed
Lyonia ligustrina	Maleberry
Lysimachia ciliata	Hairy loosestrife
Lysimachia quadrifolia	Whorled loosestrife
Melampyrum lineare	Cow wheat
Mimulus ringens	Gaping monkey flower
Mitchella repens	Partridge berry
Moneses uniflora	One-flowered pyrola
Monotropa hypopithys	Pine-sap
Monotropa uniflora	Indian-pipe
Myosotis scorpioides	True forget-me-not
Myrica gale	Sweet gale, meadow-fern
Nemopanthus mucronatus	Mountain holly
Nyssa sylvatica	Black gum
Orobanche uniflora	One-flowered cancer-root
Ostrya virginiana	American hop-hornbeam
Oxalis sp.	Wood sorrel
Parthenocissus quinquefolia	Virginia creeper
Parthenocissus sp.	Virginia creeper
Polygala paucifolia	Fringed polygala
Polygonum sagittatum	Tearthumb
Populus grandidentata	Large-toothed aspen
Populus tremuloides	Quaking aspen
Potentilla canadensis	Canadian cinquefoil
Potentilla simplex	Old-field cinquefoil
Potentilla sp.	Cinquefoil
Prenanthes sp.	Rattlesnake root
Prenanthes trifoliolata	Gall-of-the-earth
Prunus pennsylvanica	Fire cherry
Prunus serotina	Black cherry
Prunus virginiana	Choke cherry
Prunus sp.	Cherry
Pyrola elliptica	Shinleaf
Pyrola rotundifolia	Round-leafed pyrola
Pyrola sp.	Pyrola
Pyrus malus	Apple
Quercus alba	White oak
Quercus ilicifolia	Scrub oak
Quercus rubra	Red oak
Quercus sp.	Oak
Quercus velutina	Black oak
Ranunculus recurvatus	Buttercup
Ranunculus sp.	Buttercup
Rhamnus frangula	Alder-buckthorn
*Rhamnus sp	Buckthorn
Rhododendron canadense.	Rhodora
Rhododendron sp.	Rhododendron
Rhododendron viscosum	Swamp azalea
Rhus copallina	Winged sumac
Rhus glabra	Smooth sumac
Rhus sp.	Sumac
Ribes glandulosum	Skunk currant
Ribes hirtellum	Bristly currant
Ribes sp.	Currant
Rosa multiflora	Multiflora rose
Rubus allegheniensis	Black raspberry
Rubus flagellaris	Dewberry
Rubus hispidus	Swamp dewberry
Rubus idaeus	Raspberry
Rubus sp.	Blackberry
Rumex acetocella	Sorrel
Sambucus canadensis	Common elder
Sambucus pubens	Stinking elder
Sassafras albidum	Sassafras
Sedum purpureum	Garden orpine
Senecio aureus	Squaw weed
Solanum dulcamara	Nightshade
Solidago sp.	Goldenrod
Sorbus aucuparia	Mountain ash
Spiraea alba var. latifolia	Meadowsweet
Spiraea tomentosa	Steeple bush
Symphoricarpos albus	Snowberry
Syringa vulgaris	Common lilac
Taraxacum officinale	Common dandelion
Thalictrum polygamum	Tall meadow rue
Thalictrum sp.	Meadow rue
Tiarella cordifolia	Foam flower
Tilia Americana	Basswood
Triadenum sp.	St. John's wort
Trientalis borealis	Starflower
Ulmus americana	American elm
Ulmus rubra	Slippery elm
Ulmus sp.	Elm
Vaccinium angustifolium	Low-bush blueberry
Vaccinium corymbosum	High-bush blueberry
Vaccinium macrocarpon	American cranberry
Vaccinium sp.	Blueberry
Vaccinium pallens	Early sweet blueberry
Veronica officinalis	Common speedwell
Viburnum acerifolium	Maple-leafed viburnum
Viburnum alnifolium	Hobblebush
Viburnum cassinoides	Witherod

Viburnum dentatum var. lucidum	Southern arrow wood
Viburnum lentago	Nannyberry
Viburnum sp.	Viburnum
Viola blanda	Mild violet
Viola conspersa	Dog violet
Viola cucullata	Marsh violet
Viola macloskii ?	
Viola sororia	
Viola sp.	Violet

Monocots

Andropogon scoparius	Bluestem
Anthoxanthum odoratum	Sweet vernal grass
Arisaema sp.	Jack-in-the-pulpit
Arisaema triphyllum	Small jack-in-the-pulpit
Brachyelytrum erectum	
Carex argyrantha	Silvery-flowered sedge
Carex (bracteosae group)	
Carex canescens	Silvery bog sedge
Carex communis	Colonial sedge
Carex crinita	Long-haired sedge
Carex debilis	Weak sedge
Carex folliculata	Follicle-bearing sedge
Carex gracillima	Slender sedge
Carex intumescens	Swelled-up sedge
Carex laxiflora	Loosely-flowered sedge
Carex (laxiflora group)	
Carex leptalea	Delicate sedge
Carex normalis	Right-angled sedge
Carex novae-angliae	New England sedge
Carex (ovales group)	
Carex pensylvanica	Penn. sedge
Carex platyphylla?	Broad-leaved sedge
Carex rosea	Rose-like sedge
Carex sp.	Sedge
Carex (stellulatae group)	
Carex stricta	Erect sedge
Carex stipata	Crowded sedge
Carex swanii	Swan sedge
Carex sylvatica	Sedge-of-the-woods
Carex trisperma?	Three-seeded sedge
Carex vestita	Clothed sedge
Carex vulpinoidea	Foxtail-flowered sedge
Clintonia borealis	Yellow clintonia
Convallaria majalis	Lily of the valley
Cypripedium acaule	Pink lady's slipper
Danthonia spicata	Junegrass
Eleocharis sp.	Spike-rush
Epipactis helleborine	Helleborine
Festuca ovina	Sheep festcue
Glyceria striata	Fowl-meadow grass
Goodyera pubescens	Rattlesnake plantain
Goodyera tesselata	Checkered rattlesnake plantain
[Grass species]	
Habenaria bracteata	
Habenaria sp.	Orchis
Iris versicolor	Blue flag
Juncus effusus	Soft rush
Lilium philadelphicum	Wood lily
Lilium sp.	Lily
Luzula sp.	Woodrush
Maianthemum canadense	Canada mayflower
Medeola virginiana	Indian cucumber root
Orchid sp.	Orchid
Oryzopsis sp.	Rice grass
Panicum latifolium	Panic grass
Polygonatum pubescens	Hairy Solomon's seal
Polygonatum sp.	Solomon's seal
Sisyrinchium sp.	Blue-eyed grass
Smilacina racemosa	False solomon's seal
Smilax herbacea	Jacob's ladder
Smilax sp.	Greenbrier
Streptopus sp.	Twisted-stalk
Symplocarpus foetidus	Skunk cabbage
Trillium cernuum	Nodding trillium
Trillium sp.	Trillium
Trillium undulatum	Painted trillium
Uvularia perfoliata	Bellwort
Uvularia sessilifolia	Wild oats
Veratrum viride	False hellebore

Fern Allies

Equisetum arvense	Common horsetail
Equisetum sylvaticum	Horsetail
Diphasiastrum digitatum	Trailing evergreen
Diphasiastrum tristachyum	Ground pine
Huperzia lucidula	Shiny clubmoss

Lycopodium annotinum	Bristly clubmoss
Lycopodium clavatum	Common clubmoss
Lycopodium dendroideum	Northern ground pine
Lycopodium hickeyi	Hickey's clubmoss
Lycopodium obscurum	Tree clubmoss
Lycopodium sp.	Clubmoss

Ferns

Athyrium filix-femina	Lady fern
Athyrium thelypteroides	Silvery spleen
Botrychium virginianum	Rattlesnake fern
Cystopteris fragilis	Fragile fern
Dennstaedtia punctilobula	Hay-scented fern
Dryopteris cristata	Crested wood fern
Dryopteris filix-mas	Male fern
Dryopteris intermedia	Spinulose wood fern
Dryopteris marginalis	Marginal shield fern
Dryopteris spinulosa	Spinulose wood fern
Gymnocarpium dryopteris	Oak fern
Onoclea sensibilis	Sensitive fern
Osmunda cinnamomea	Cinnamon fern
Osmunda claytoniana	Interrupted fern
Osmunda regalis	Royal fern
Polypodium virginianum	Rock polypody
Polystichum acrostichoides	Christmas fern
Pteridium aquilinium	Bracken fern
Thelypteris	New York fern
noveboracensis	Marsh fern
Thelypteris palustris	Beech fern
Thelypteris phagopteris	

Gymnosperms

Juniperus communis	Common juniper
Juniperis virginiana	Red cedar
Larix deciduas	Deciduous larch
Picea rubens	Red spruce
Picea sp.	Spruce
Pinus resinosa	Red pine
Pinus rigida	Pitch pine
Pinus strobes	White pine
Taxus canadensis	American yew
Tsuga canadensis	Hemlock

In 2001, Professor Robert Bertin (College of the Holy Cross, Worcester) identified a vigorous population of 100-200 plants of *Polygala verticillata* (whorled milkwort) along the Prison Camp Road. This species is a Watch List species in Massachusetts, which means that it remains on the Natural Heritage and Endangered Species Program list of species that are suspected to be rare or declining, but for which information is currently lacking.

The above serves as a starting point for assessing the diversity of plant species present on the Ware River watershed. Based upon historic records from the Herbarium and other sources, there is some likelihood that a comprehensive search would find additional, uncommon plant species on the Ware River watershed. A list of these species is found in Appendix II, along with a general list of habitats in which rare plant species are likely to be present.

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3 Water Resources

3.1 Historical Perspective on Water Resources at Ware River

The community of Boston commenced its search for clean water in 1652, when the General Court of the Massachusetts Bay Colony incorporated the Water Works Company. Under the Company's direction, water was delivered to Boston from wells through wooden pipes to a wooden storage reservoir from which water was distributed throughout the community. By the late 18^{th} Century, this system was no longer adequate to supply the needs of the expanding population. Consequently, the supply system was extended to Jamaica Pond in Roxbury.

Water supply problems continued to plague the city throughout the 19th Century. Expansion of the supply system was initiated only after the supply needs became critical. By the 1830s the system was inadequate, and the decision was made to expand. In 1849, an aqueduct was completed to deliver water to the city from Lake Cochituate in Natick. The system was expanded again in 1873, with the completion of an aqueduct to bring water from the Sudbury River into the supply system.

1870 - 1890 was a period of rapid growth for the City of Boston and the surrounding municipalities. The demand for high quality drinking water grew beyond the system's capacity. In 1893, the legislature directed the State Board of Health to develop plans to expand the supply system. Three alternatives were investigated: Lake Winnipesauke in New Hampshire, the Merrimac River, and the Nashua River above Clinton. After careful consideration, Winnipesauke was eliminated because of the potential difficulties of dealing with another state. The Merrimac Plan was abandoned due to inferior water quality. Consequently, in 1895, the board recommended that the Nashua River above Clinton be developed as an additional water supply. The report called for the construction of a dam in the Town of Clinton and an aqueduct connecting the proposed reservoir with the Sudbury system. This report led to the formation of the Metropolitan Water Board and the implementation of construction plans. Upon completion in 1908, the new dam created the Wachusett Reservoir. The Wachusett Reservoir had a capacity of sixty-three billion gallons, and the aqueduct had the capacity to deliver 300,000 gallons of water daily.

It was obvious by 1919 that the system could not indefinitely continue to supply the growing water needs of the Metropolitan Water District. The legislature recommended that the Boston Metropolitan Water District investigate potential supplies, resulting in the 1922 Goodnough Plan. This plan recommended the construction of an aqueduct from Wachusett Reservoir into the Ware River valley to divert the flood flows of the Ware to Wachusett. It went on to recommend the construction of a dam to impound the waters of the Swift River and the extension of the Wachusett-Coldbrook Aqueduct into the Swift River valley. It further advised that the system be expanded to the Millers and Connecticut Rivers. It was felt that this would provide a sufficient supply of water to the Metropolitan Water District for the foreseeable future.

There was considerable opposition to this plan in the Western part of the state. From 1925 until 1927, the plan was debated and reexamined. In 1927, the legislature enacted Chapter 321 of the Acts of 1927, approving the Goodnough Plan with the exception of Millers and Connecticut diversions and paving the way for the start of construction of the Quabbin Reservoir and the Ware River intake.

The Ware River intake works in South Barre and the Coldbrook-Wachusett aqueduct were completed in 1931. In that year, approximately thirteen billion gallons of water were diverted from the Ware River to the Wachusett Reservoir.

3.2 Ware River Intake Works

Roger Lonergan Intake Works, Shaft #8

The Roger Lonergan Intake Works is located on the south side of Route 122 about four miles east of Barre center, in the Ware River at the point where the river passes over the Quabbin aqueduct. The Intake Works are designed to divert water from the Ware River through Shaft No. 8 into the Quabbin-Wachusett aqueduct for delivery to either the Quabbin or Wachusett Reservoirs. Diversion normally goes to Quabbin, where a baffle dam forces water diverted from the Ware River to flow around Mt. Zion before reaching Shaft 12, through which Quabbin's water flows to the Wachusett Reservoir. This design allows the highly organic water of the Ware River to be mixed and stored with the less organic water of the Swift River before passing to Wachusett Reservoir.

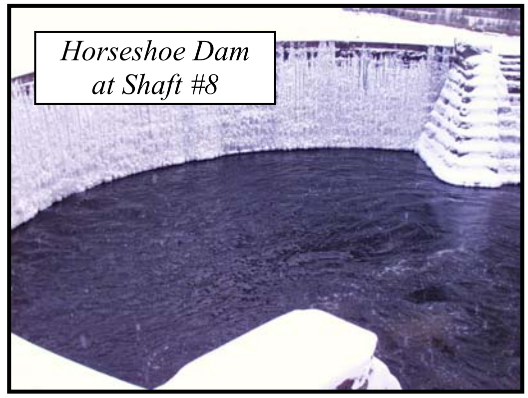
Diversion of water from the Ware River is subject to the following legal restrictions, under the Acts of the Massachusetts State Legislature Chapter 375, Acts of 1926:

- No water may be diverted from the Ware River on any day when the natural flow of the river is less than eighty-five million gallons
- A total of eighty-five million gallons of water must be released down the Ware River on each day during which diversion takes place
- No diversion shall take place during the period between May 31 and December 1 in any year unless such diversion is first approved by the State Department of Public Health

An additional restriction, under a decision of the War Department, states that no diversion shall take place during the period between June 15 and October 15 of any year. This has been interpreted to mean that diversion must stop at midnight on June 15 and cannot be resumed before midnight on October 14 of any year.

The Intake Works at Shaft No. 8 are a siphon system. Water is drawn from above the dam into the intake works through six siphon spillways. From the spillways the water enters the valve pit where four butterfly valves are mounted to regulate the amount of water entering the shaft. The large metered valve has a capacity of 620 million gallons daily, while each of the three unmetered valves has a capacity of slightly less than 600 million gallons a day. The total capacity is slightly less than 2.4 billion gallons daily. The valves direct the water onto cast iron plates with helical vanes mounted on the walls of the shaft. Centrifugal force maintains a smooth discharge of water from the valves around the circumference of the shaft. The water can then be gravity-fed through the aqueduct in either direction.

3.3 Surface Waters



Horseshoe Dam at Shaft #8

The impoundment at Roger Lonergan Intake at Shaft No. 8 in Barre is classified as a "run of the river reservoir." Residence time is short and the water maintains the character of river water. The Ware River derives its character from water inputs from Barre Falls Dam, the Burnshirt River, Natty Pond Brook, Parkers Brook, subsurface flow from forestland, and small amounts of overland runoff from impervious surfaces in the watershed. Each of these inputs contributes markedly different qualities to the water at the Intake.

Barre Falls Dam is a flood control facility managed by the U.S. Army Corps of Engineers. Typically, it holds back the peak flow in the spring and then discharges it gradually. Dissolved oxygen can decrease in the impoundment, especially if leaf-out occurs before water levels return to normal pool. However, substantial aeration occurs by way of a mile-long rocky ravine immediately below the dam. The Burnshirt River, Canesto and Natty Pond Brooks combine and enter the Ware River below the ravine. Normal, unimpeded flows through the dam are high in dissolved organic compounds (DOC) and color, derived from the peaty meadows of the East and West Branches of the Ware River above the dam. Extensive peat deposits along Natty Pond Brook contribute significant color and DOC and decrease dissolved oxygen. These qualities are somewhat reduced through mixing with waters of the Burnshirt River and Canesto Brook.

Parkers Brook follows Route 122, crossing it several times. Numerous direct road runoff channels from Route 122 may contribute metals, salt and sediments. Route 122 also follows the Ware River from below Parkers Brook to the Intake, with the same channelized road runoff. For the most part, however, the river flows through Division-controlled properties on the Ware River watershed, which are predominantly forested except for a network of gravel roads.

Besides the impoundment at the Intake, which has already been described as having river-water character, the Division owns or controls many small dammed ponds. These ponds may exert some influence over downstream water quality, but they were built for other purposes, such as mill ponds. While their locations may not be ideal, they are perceived to contribute positive qualities to the water, such as reducing dissolved organic compounds.

3.4 Water Yield

Historically, growing demands on Boston's water supply system led to repeated efforts to develop land management strategies that would increase water yield. In the past decade or more, the MWRA has devoted considerable efforts to demand management, and the overall system demand has significantly decreased since 1988, primarily due to water conservation efforts. The MWRA has stated that demand is projected to remain below safe yield of the system for the immediate future. This condition may be influenced by significant droughts, increased pressure to add new users to the system, and economic pressures to generate revenue. While water quality considerations will drive management decisions for this 2003-2012 Ware River Land Management Plan, water yield will remain an important consideration in land management planning.

4 Land Protection

4.1 Land Use/Land Cover in the DCR/DWSP Watersheds

Land use and development patterns in a watershed influence the hydrology and water quality of its streams and lakes/reservoirs. They are important considerations in determining appropriate protection measures for watersheds. Generalized land use/land cover categories, and population density for the Wachusett, Quabbin, and Ware watersheds are shown in Table 2. Land Use for the Ware River is mapped in Figure 3.

TABLE 2: LAND USE/LAND COVER BY PERCENT (EXCLUDING RESERVOIR SURFACE AREAS)

Land Use/Land Cover	Quabbin Reservoir	Ware River	Wachusett Reservoir
Forest	87%	74.7%	67%
Wetland	6%	11.4%	8%
Agriculture	3%	4.7%	8%
Residential	1%	3.3%	9%
Commercial/Industrial	0.1%	0.7%	0.6%
Open Water	0.3%	2.6%	2%
Other	3%	2.6%	7%
Persons per sq.mi.	***16***	***77***	***284***

Although the watershed system is sparsely developed, the level of developed land is lowest in the Quabbin watershed and becomes more developed and populated eastward to the Wachusett watershed. Note that no wastewater treatment plants or industrial discharges exist within any of the three watersheds.

4.2 Protected Lands in the DCR/DWSP Watersheds

Overall, the Division directly controls about 42% of the entire watershed system, exclusive of the reservoirs themselves. The Division controls approximately 57% of the Quabbin watershed, 38% of the Ware River watershed and 26% of the Wachusett watershed (Table 3). Other state agencies, non-profit land conservation organizations and municipalities own and protect another 21% of the combined watersheds.

FIGURE 3: WARE RIVER LAND USE/LAND COVER MAP

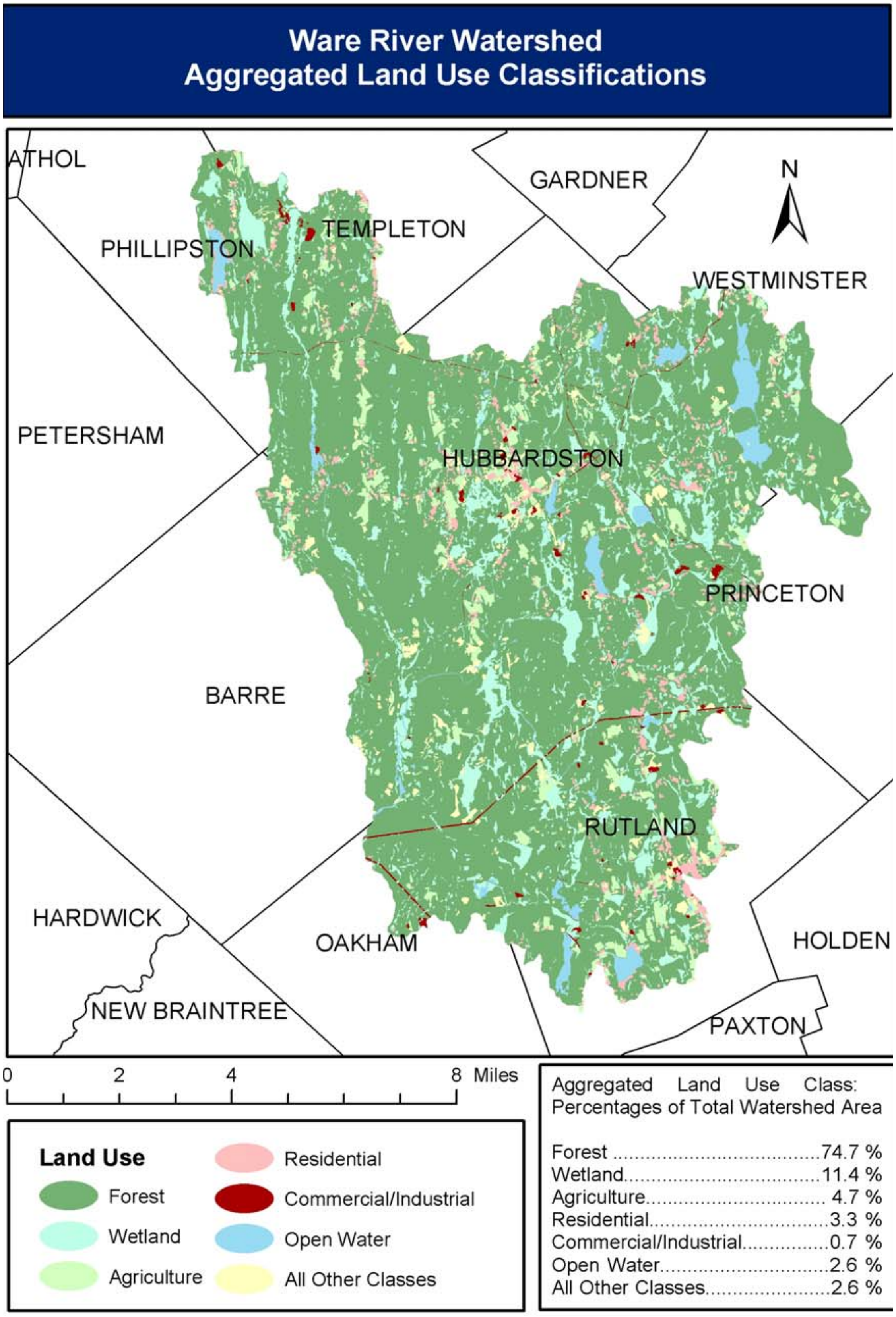


TABLE 3: DCR/DWSP AND OTHER PROTECTED LAND

	Open Space as % of Watershed*		
Watershed	DWSP-Controlled	Other Protected**	Total Protected
Quabbin Reservoir	57	18	75
Ware River	38	20	58
Wachusett Reservoir	26	26	52
Combined	42	21	63

* Watershed area excluding reservoir surface.
** Includes lands owned by other state agencies, local government, and private entities.

There is a long history of interagency cooperation among those agencies with a stake in the lands on the Ware River watershed. The Division of Fish and Game signed a cooperative agreement with the MDC in 1956 and established the Barre Falls and Hubbardston Management Areas. The MDC did habitat restoration work by reclaiming approximately 40 acres of overgrown field in the1960s and 1970s. More recently, MassWildlife evaluated many sites on the watershed for inclusion in the Upland Habitat Restoration Program, which is designed to respond to the loss of early successional habitat across the state by returning sites to early seral stages.

The Army Corps of Engineers owns 500 acres of land (acquired from MDC in 1953) in the center of Division holdings, and leases approximately 1,800 acres of Division property for emergency flood storage. These two agencies cooperate on a number of activities that include flood control, access control, road and bridge maintenance, and habitat restoration. The Division has benefited from Corps programs that identified rare and endangered species and habitats, and significant prehistoric and historic sites shared by the two agencies.

The MA Department of Conservation and Recreation (DCR), Division of State Parks and Recreation (DSPR) leases about 250 acres of Division land for Rutland State Park, owns two former railroad lines, and is involved in helping to set policy for the Midstate Hiking Trail that crosses through Division holdings in the Ware River watershed. The DWSP and the DSPR work together on recreational activity concerns, including road maintenance and access problems. The Division has benefited from this relationship over the years in dealing with a variety of insect and disease problems in the forest.

4.3 DCR/DWSP-Controlled Land in the Ware River Watershed

4.3.1 Boundaries

Marking and maintaining land ownership boundaries is an important component of watershed protection. When boundaries are not respected and activities detrimental to the water supply occur, the protection value of these lands is diminished.

Many kinds of encroachments have occurred on Division property. These encompass a wide range of activities resulting in a variety of impacts on protection values. The following are examples of encroachments reported at Division boundaries in the past:

- Destruction of property through the removal of trees and plants, gravel, or topsoil; grading, paving, or filling of soil or ground cover; or removal or disturbance of boundary monuments, stone walls, or line trees.
- Impairment of water and soil through the dumping or storage of refuse or hazardous materials, grazing of animals, and manure storage
- Construction of buildings, docks, or fences

Illegal dumping on DWSP land

Boundary maintenance is the best means of reducing encroachment problems. Maintained, visible boundaries protect the integrity of property, provide a frame of reference for policing and monitoring, and are essential proof when a dispute or encroachment occurs. There are approximately 125 miles of boundary surrounding Division lands on the Ware River watershed. Most of this distance traverses remote areas between paved roads.

Several steps are needed to improve the Division's boundary maintenance program. First, a maintenance schedule will be established so that within each ten year management cycle all critical boundaries are brushed, painted, and reposted. During these visits missing or damaged bounds, encroachments, or problems will be noted, and the information passed to the superintendent. The Division is considering redesigning boundary tags to improve their visibility.

Secondly, to improve property identification and to improve monitoring, signs and markers will be erected where property lines intersect paved roads. This is especially important on the properties outside the General Taking (the original land purchase for the creation of the water supply system). All new acquisitions will be surveyed and bounded at the time of purchase to clearly identify property lines and reduce work required by in-house engineering staff.

The Division is considering alternatives to forestry personnel to accomplish boundary maintenance. This work could be contracted out to the private sector. A single contract could be written including all boundaries within the watershed, or an annual contract could be written for sections of boundary maintenance. Another option under consideration is the use of summer employees to maintain segments of boundary each year, although this approach would require monitoring to ensure consistency. Division engineering staff would have responsibility for supervision of boundary maintenance done through contracts or other agreements.

4.3.2 Role of DCR/DWSP Watershed Rangers in Land Protection

The Division controls about 42% of a 257,000-acre watershed and reservoir system, which provides drinking water for nearly 2.2 million people. While public access to this system is regulated by policy and by physical barriers such as gates, both appropriate and inappropriate uses occur throughout the year. For several decades prior to 1992, the Metropolitan Police, who had jurisdiction in any town that contained MDC property, patrolled the watershed system. In 1992, the MDC police force was consolidated with the State Police and other police departments. A Memorandum of Understanding was established with the MA State Police to provide the same services to the MDC watersheds that were carried out by the former Metropolitan Police. Following the consolidation, the MDC felt it would be prudent to create a limited ranger program to complement the efforts of the police, including rangers specifically assigned to watershed protection. MGL Ch. 92, s. 34b specifies the authority of these rangers, as follows:

"The Metropolitan District Commission is hereby authorized to establish a park ranger program within the department to preserve, maintain and protect the parks, reservations, historic sites and open space and to ensure the environmental integrity of properties under the care, custody and control of the commission."

Within the Mission Statement of the MDC Park Ranger Unit (which included Watershed Rangers), four primary objectives are identified:

1. Resource Protection: Park Rangers will provide active and visible uniformed patrols of MDC properties and facilities in an effort to discourage improper use and criminal activity. Park Rangers issue verbal or written warnings and non-criminal citations to individuals who violate MDC Rules and Regulations and contact the MA State Police to address criminal activity.
2. Visitor Services: Park Rangers will assist visitors to MDC properties by providing them with information as requested, rendering emergency service when necessary, and promoting educational and recreational opportunities through various programs and activities.
3. Education and Community Relations: Park Rangers will encourage appreciation and proper use of MDC resources through various outreach programs. This includes maintaining an active working relationship with park patrons, user/friends groups and the owners of private properties abutting MDC lands.
4. Reservation and Historic Site Management: Park Rangers will assist in proper maintenance and protection of properties and facilities by implementing measures for damage prevention, conducting routine on-site inspections, promptly reporting and documenting maintenance problems, and taking and documenting corrective action.

The primary function of the Division's Watershed Rangers is to protect drinking water resources by conducting regularly-scheduled patrols of the watersheds. Watershed Rangers provide a visual, uniformed presence on Division lands and pro-actively patrol to help solve problems, such as vandalism, inappropriate recreation uses, illegal dumping and accidents within the watershed that may degrade water, forest, wildlife and/or cultural resources. The Rangers rely on rules education rather than enforcement to seek compliance. Rangers do not have law enforcement powers. When situations occur that require law enforcement personnel, Watershed Rangers communicate these to the State Police and other enforcement agencies.

Watershed Rangers are "good will ambassadors" and not only show a positive presence but also speak on behalf of the agency and the Division about proper watershed stewardship and drinking water protection to community or other organization gatherings, children, school groups, service organizations, senior groups, etc. Through their positive interaction with visitors, rangers protect these open spaces and encourage all people to do the same by obeying all watershed rules and regulations for specific Division reservoirs and the system as a whole.

Watershed Rangers provide security for Division facilities and other designated buildings, and regularly monitor potential trouble spots on the watershed. Special use and group permits may be checked by Rangers to ensure that permittees are in compliance with their permit. Rangers keep a daily log of their patrolling activities. Incidents are documented and are referred to the appropriate authorities. Rangers also aid in placement of signage on Division lands throughout the watershed, to assure the public has ample opportunity to become informed about access regulations.

Since 1996, the number of Rangers assigned to the Quabbin/Ware River watersheds has grown from one to seven. Ranger patrols include pro-active surveillance of DCR/DWSP-owned lands with emphasis on popular access locations around the Ware River watershed. Watershed Rangers have monitored authorized activities, including: horseback and snowmobile rides; orienteering; fishing from shore and boats and ice fishing; camping and hunting in designated areas. Rangers also monitor and report on the condition of trails and signs, ice conditions on designated ponds, as well as illegal activities including dumping of trash and debris, ATV and off road vehicle use, fires, and target shooting. In addition, Watershed Rangers are trained as emergency first responders and have undertaken ice rescue training. During Fiscal Year 2003, Watershed Rangers spent an average of 16-20 hours per week covering responsibilities on the Ware River watershed.

Historic Ware River road

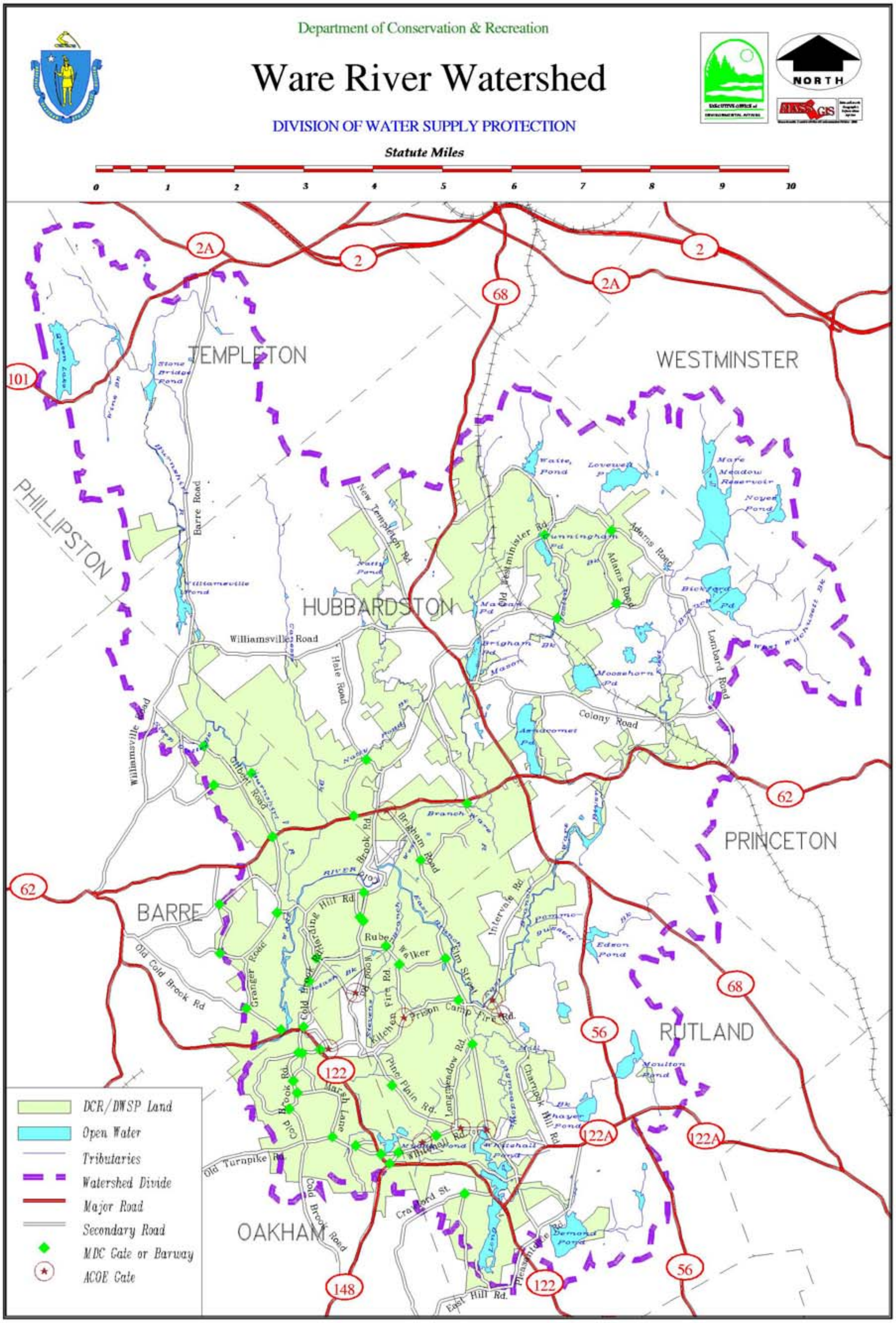
4.3.3 Ware River Roads

4.3.3.1 History and Current Condition

Most roads on Division properties on the Ware River watershed are a legacy left from the communities that predate Division acquisition. They vary from well-built and maintained roads connecting adjoining communities to primitive farm lanes serving a single dwelling. Municipal roads that fell within the General Taking were discontinued by the four towns involved. Exceptions include the Old Worcester Road and the northern section of Gilbert Road in Barre and Ware, and the Barracks Hill Roads in Rutland. While historic, engineered town roads are generally still the highest quality roads on Division properties, these were built to accommodate smaller, lighter vehicles than are common today. Many of the lower quality roads originally provided access to fields, pastures and woodlots and were improved to various degrees by the MDC following reservoir construction. The present road system represents a fraction of the roads and ways that were in use during the height of 19th century agricultural activity in the region. An examination of any wooded parcel will reveal numerous wheel tracks leading from field to pasture to woodlot.

At the time of the General Taking, the Metropolitan District Water Supply Commission (now the DCR/DWSP) assumed control and maintenance responsibility from the towns for the gravel roads within its properties. In the first few decades, road use was light and maintenance requirements were minimal. In the 1960s, four-wheel drive trucks and recreational vehicles became popular and use of the watershed intensified. These activities severely damaged the access road system. There were limited funds and labor available to repair and maintain the roads.

FIGURE 4: WARE RIVER GATES AND ROADS



By the end of the 1970s some roads were impassable, some were usable only in the driest seasons and some could be used but only with the greatest caution. The combination of excessive use and deferred maintenance left conditions that were prone to erosion and tributary siltation during storm events.

It was apparent in the early 1980s, at the start of the last management period, that lack of access control was jeopardizing the Division's ability to maintain and protect watershed lands and associated water resources. To address the problem a program was presented in the last management plan to restrict vehicle access. A principal objective of this initiative was to reduce road maintenance by concentrating vehicle use on ways maintained as all-weather roads. Another objective was to limit vehicle access on steep gradient roads that are difficult to maintain and at greater risk to erode. A third objective was to temporarily abandon a portion of the road network that was deemed nonessential, in part to create some larger blocks of roadless forest.

During the 1980s, eight gates and forty culverts were installed in the DCR/DWSP road system at Ware River, and approximately 12,000 cubic yards of gravel were spread. In 1988, the Ware River Recreation and Public Access Plan was approved by the MDC. It formalized access restrictions, including seasonal and daily closings for roads, installation of gates (38 proposed), and restrictions on recreational vehicles. Coincidental with approval of the plan, the Division obtained the needed personnel and equipment to implement the program. During the early 1990s, the proposed vehicle access restrictions were put in place, and thirty-nine steel gates and sixty-eight barways were installed. During the same time period, approximately 18 miles of road were upgraded to an all-weather status by installing more than 100 culverts to improve drainage and by spreading approximately 20,000 cubic yards of processed gravel. At the same time, approximately 18.5 miles of access road were gated off and their status upgraded to allow limited use during most seasons of the year. Another 20.3 miles of roads were blocked and abandoned on a temporary basis. These roads may be opened up and used for short periods of time for emergencies or for management activities. In the subsequent decade, staffing was reduced following the completion of the upgrades. However, motorized access continued to increase as a result of improved travel surfaces and expansion of off-road motorized and non-motorized sports.

In order to maintain the stability of the Division roads on the Ware River, efforts will continue to be made to bring the level of use in line with the Division's ability to repair, maintain, and improve the road system. Road repairs and improvements create a continuing dilemma in that these improvements generally result in greater public use. However, when repairs and improvements are not completed, both ATV and non-motorized traffic, including horse traffic, continue to expand while the ability of the Division to patrol and control use of these areas is limited. It is Division policy to maintain sufficient access to allow required management activities, within the constraints of staff and financial resources. Setting policies for non-management access is primarily the subject of periodically updated access plans for each watershed, but controlling unauthorized access will be a consideration in all management activities (for instance, closing and blocking access to log landings and skid trails at the completion of harvesting operations).

4.3.3.2 Road Maintenance Priorities and Objectives

The internal forest road network on Division lands in the Ware River watershed provides vehicle access for important watershed management activities such as forest management, fire protection, water quality sampling, patrolling and policing, and emergency vehicle access. The purpose of this section is to discuss the current state of the Division road network and maintenance needs. As mentioned above, in addition to the physical condition of the roads, the current Access Plan (most recent update January 2000) for the watershed determines the public, non-management use of all Division roads.

In total, the Division has care and control of approximately 57 miles of gravel access road on the Ware River watershed, as well as many miles of non-gravel road. There are three classes in the permanent road system, and a fourth class of temporary, non-gravel roads:

1. Class 1 roads are 10-14 foot wide, four season, permanent roads with adequate drainage and structure to sustain year-round use, if necessary. The road surface is processed gravel, and drainage (vegetated ditches) is adequate to protect the road surface under most conditions. These roads receive relatively high use and are generally kept open and passable from at least May to January, although subject to closing anytime that conditions warrant. (Coldbrook Road is usually plowed and left open through the winter for local access, but closed for periods in the spring). There are approximately 5 miles of Class 1 roads on the Ware River Watershed.
2. Class 2 roads are 10-12 foot wide, permanent roads that are closed seasonally. Class 2 roads were not constructed and are not maintained to withstand traffic during periods of frequent freezing / thawing, nor when the water table is high, although drainage is sufficient to protect the road surface during most climatic conditions. Class 2 roads are generally open from May 1 to January 1, unless unusual conditions require closing. The road surface is either bank-run or processed gravel, but these roads are at least partially vegetated during the growing season.
3. Class 3 roads are 8-12 foot wide, intermittent use, permanent roads. These are generally grass-covered roads that may or may not be gravel-based. Class 3 roads are maintained through periodic mowing and maintenance of drainage, but they are infrequently used, and public access is restricted except that some of these roads are open during hunting seasons. There are approximately 52 miles of road on Division properties in the Ware River watershed that are classified as either Class 2 or Class 3.
4. Class 4 roads are temporary roads used for timber harvest access by forwarders and/or skidders. Once harvesting is complete, these roads are stabilized, barricaded, and allowed to revegetate. As these roads are temporary, the number of miles of active Class 4 roads on the Ware River watershed is variable from year to year.

The proper maintenance of forest roads is important to both ensure reliable access and to minimize erosion and the resulting sedimentation of tributaries. A properly crowned road surface comprised of well-packed material with adequate drainage features should be the goal for all of the Class 1 and 2 roads on Division property. The Class 3 roads have less stringent requirements that may be met merely by the maintenance of a healthy grass cover and occasional restoration of drainage, and occasional restoration of proper crowning to direct water off the road surface.

During times when budgets are contracting, the actual miles of roadway maintenance that can be accomplished in any year will be less than needed to maintain optimal roadway stability. In order to complete the most critical maintenance projects first, strategies will be developed annually to prioritize the use of resources available in any given fiscal year

The greatest road-related threat to water resources is the crossing of streams and rivers by roads. Extensive research has demonstrated that improved design, building, and maintenance of roads can greatly reduce road-related surface erosion within sections of roadways. The most important implications of these studies for Ware River roads is to set the priorities on controlling use or the improvement of drainage structures and road surface conditions (crowning, and either gravel or vegetative surface, depending on traffic). The objective in all cases is to assure that the road is capable of handling the anticipated traffic load without compromising its ability to handle drainage needs.

In order to better understand the current state of roadway stream crossings, a survey is proposed for this management period to categorize the existing crossings, determine the potential threats to the water system, and propose potential mitigations. A GIS overlay of Ware River roads and water courses will be the first step in categorizing roads for maintenance priority. The following additional data will be collected for this purpose:

- *Class of road:* Class 1 roads, because of their size and traffic load, can produce greater sediment movement from road surface to streams than smaller, less traveled Class 2 or 3 roads.
- *Gates:* The current location of gates and the conditions/schedule for opening or closing these gates provides control over the annual use and therefore the maintenance requirements.
- *Slope:* The greater the slope the higher the erosion potential.
- *Drainage:* After a century of travel and maintenance, many of the historic town roads comprising the watershed road system are 3 to 5 feet below original grades. Sandwiched between historic stonewalls, roadside ditches become shallow and ineffective. These constraints inhibit the construction of relief ditches and drainage structures needed to dissipate storm water and meet the standards of agency Conservation Management Practices for road maintenance (described below). Where necessary, these roads will be blocked and abandoned until such time as a solution to the drainage problem can be designed and implemented.
- *Surface material:* The quality of road surface material can greatly affect erosion potential. Processed gravel, properly graded, crowned, and compacted, is the most common material used in reconstruction projects on the watershed. The USDA Forest Service routinely uses asphalt pavement on steep roadways crossing streams, but the Kelly-Wetmore Act prohibits "hardening of road surfaces" on Division properties. An impervious surface may increase the velocity of storm runoff but correctly designed can result in reduced migration of sediments from the road surface into streams. On lightly traveled roads a grass surface maintained by mowing can provide increased protection from sediment movement.

Division staff has determined the basic level of maintenance required to maintain the current network of roads on Ware River properties on an annual basis:

- Class 3 roads will be inspected and kept free of downed branches and debris. Water control structures will be cleaned, mowed, and maintained to prevent erosion. This includes the installation of water bars and/or dips and the recrowning of the road surface following a period of use of these roads for management purposes. As labor and materials are available, gravel (1.5" or smaller processed and bank run) will be utilized to strengthen the roadbed and crown and to top dress the travel surface of a portion of the Class 3 roads.
- Portions of Class 1 or 2 roads will receive upgraded drainage features. Grass-lined and riprap lined ditches will lead to retention basins that allow sediment to settle out before runoff enters surface waters. Drainage outlets that are currently directed toward surface waters will be redirected to upland areas.
- As resources allow, up to 18 miles of Class 1 or 2 roads will be graded and crowned, with ditches and culverts inspected and cleaned. 1.5" or smaller processed gravel will be placed as needed on these roadways to maintain contour, surface integrity, and stability.
- It is the Division's intention to limit washouts by replacing under-sized culverts with structures that will meet appropriate standards. Culverts will be inspected on Class 1 and 2 roads and those found to be sub-standard will be prioritized and replaced as labor and materials are available. At a minimum,

the Division intends to replace three small (12" to 18") culverts and one large (>36") culvert annually. In addition, the Division will work to continue installation of overflow spill areas (reinforced, low areas on a road adjacent to major streams) capable of spilling the flow from a 100 year flood (1% chance of occurrence in any given year) on major tributaries.

Current (2003) maintenance staffing in the Quabbin Section is at a bare minimum. In the past, Ware River maintenance staff included a Foreman, a heavy equipment operator and a laborer. As this plan is being written, the Foreman is retiring and the Maintenance Equipment Operator and Laborer positions are vacant. It does not appear staffing will return to former levels in the near future. Road maintenance projects at Ware River have traditionally been completed by supplementing the Ware River staff with equipment operators from the Quabbin Section watershed maintenance staff at the New Salem field office. These highly skilled operators with their specialized equipment are able to perform a wide variety of complex construction and maintenance tasks. Each year this group has spent as many as 6 to 8 weeks in the Ware River watershed working on larger projects. These have included: reconstruction of 30 miles of Class 1 and Class 2 roads, installation of the Ware River field office septic system, replacement of bridge decking on Comet Pond and Brigham Road bridges, and restoration of 20 acres of recently purchased property that had been cleared, with road and drainage infrastructure installed for a proposed subdivision. The Quabbin Section is in the middle of a reorganization effort. The New Salem crew will play a more direct role in maintaining access roads and security on the Ware River watershed. This will require assigning equipment operators and/or laborers as needed for routine maintenance tasks. This effort will focus on better prioritization of tasks to allow a smaller, skilled workforce using specialized equipment to more efficiently complete tasks. With this workforce in place, Quabbin Section staff will be able to complete high priority projects in the Ware River watershed.

To date, virtually all of the gravel used to maintain the Division's Ware River road system has come from Division-controlled pits. There are presently four active gravel pits from which material is being extracted for use, including the Grainger Pit, the Pond View Pit, Shaft 6, and Shaft 7. The Division's road maintenance equipment resources improved during the past decade. If budgets allow, this equipment will expand further during the coming management period, in order to facilitate a stronger focus on improving the drainage structures on the road network.

4.3.3.3 Conservation Management Practices for Road Maintenance

NOTE: DCR/DWSP has begun to use the Canadian term "Conservation Management Practices" to replace the older term "Best Management Practices", believing that it is more descriptive. Both terms refer to efforts to create resource-protecting standards for management activities.

It is widely understood that roads represent the greatest potential source of erosion and sedimentation on an otherwise forested watershed. The "natural" state of a forested watershed includes a topsoil and duff layer that has enormous infiltration capacity and allows rainfall to travel slowly and evenly toward surface waters, with a significant amount of filtering of sediments and nutrients along the way. The proper construction of a road requires that this filter layer be removed and replaced with a durable, compacted surface. The disruption of natural flow can be mitigated with proper drainage features and maintenance, although even the most carefully constructed and maintained road remains a greater threat to water quality than an adjacent, roadless forest. While roads are a functionally necessary component of watershed protection, their construction, maintenance, and use need to be carefully considered and controlled in order to limit their impact on water quality.

Roads passing through streamside riparian areas and crossing surface waters are associated with the most extensive potential impacts to water quality. Chronic transfer of sediments to surface water is frequently associated with roads, and high concentrations of suspended sediments kill aquatic organisms and impair aquatic productivity. "Roads are especially important vectors of nutrients and other materials to aquatic ecosystems, because the buffering role normally played by riparian vegetation is circumvented through direct runoff of materials in water and sediment where roads abut or cross water bodies. Water moving on and alongside roadways can be charged with high levels of dissolved nitrogen in various forms, and sediment brings a phosphorus subsidy when it reaches surface waters." (Trombulak and Frissell, 2000) The highest priority for mitigation of road effects on water quality, therefore, should be to concentrate maintenance on road / water intersections.

The objectives of road maintenance on Division watershed lands are to provide for vehicle access to support key watershed management activities, and to minimize adverse water quality impacts associated with this road system. Activities that are dependent upon a good access road system include fire protection, forest management, water sampling, research, and ranger patrols. These activities require stable, properly-shaped and ditched road surfaces with adequate structures to manage stormwater.

To accomplish these objectives Division crews will use various mitigating procedures to protect stream water quality during routine maintenance and repair activities. These procedures are outlined below. It should be noted that specific sites might require special systems not described here, such as the use of geotextile, erosion control blankets, subsurface drainage, and riprap materials. In addition, wildlife conservation practices will be considered when constructing and maintaining roads (see section 6.3).

- *Shaping Road Surface*: The basic component of a stable road is the proper ditching and crowning of the road to allow stormwater to flow off the travel surface and be collected in the roadside ditch.
- *Relief Ditches, Relief Culverts, and Waterbars*: The frequent removal of storm water from the roadside ditch is important to limit the amount of soil and gravel that is washed from an area during an event. The spacing of the relief structures is determined by combining site data such as slope of the road, slope of adjacent woodland, soil type and depth, proximity to surface waters, and physical structure of the road. The general rule of thumb is to place relief structures as often as the landscape allows on most slopes. Relief structures, wherever possible, will not discharge stormwater within 50 feet from streams or wetlands.
- *Detention and Retention Basins:* These basins will be installed where needed during road reconstruction activities to reduce the velocity of stormwater and increase infiltration.
- *Dry Season Work*: Except for emergency repair work, some major bridge work (which may extend beyond dry periods), and emergency culvert maintenance or replacement, road work will generally be accomplished during dry periods (primarily summer), when low water flow and stable soil conditions will help mitigate impacts from soil disruption.
- *Use of Silt Fence/Hay Bales*: Whenever road maintenance work requires disturbance near wetlands, the wetland will be protected by properly installed hay bales and/or industry standard silt fence.
- *Seeding of Disturbed Areas*: Upon completion of road maintenance projects, areas of disturbed soil, including ditches and gutters will be graded and seeded with quick growing grass species. The Division has purchased a "hydro-seeder" for this purpose.
- *Special Road Surfaces*: Because of the huge variation of historical forest road construction and use, alternative road surface materials may be appropriate in limiting loss of material through erosion. Forest roads that are rarely used may be shaped and seeded with grass. Yearly mowing and culvert cleaning would then maintain these roads. Depending on location and use, these roads may also be blocked by use of barways to keep out all but essential traffic.

4.3.3.4 Internal Review Process for Developing Access Roads or Gravel Operations

Much of the roadwork conducted on the watershed is routine and of a maintenance nature. Occasionally, however, new access roads must be constructed, existing roads must be significantly upgraded, or new sources of gravel must be developed. In these cases, since the operation may result in habitat changes or produce potential impacts on water quality, wildlife, or cultural resources, the following procedure will be followed:

1. Develop a plan showing the location of the proposed work, the proposed timing for roadwork or gravel removal, and the procedures to be employed. The plan will include a detailed description and justification of the work and consideration of alternatives.
2. Consult with the Division Section Superintendent, Environmental Quality staff, Natural Resources staff, and Division archaeology staff to determine that no significant impacts will occur to water, wildlife, or cultural resources and to be certain that the staff, equipment, and resources required will be available to complete the work in the proposed timeframe.
3. Complete all necessary approvals and permits from other state or municipal authorities.
4. Acquire final approval from the Section Superintendent following consultation with and approval by the Director of Natural Resources.

4.3.3.5 Minimizing Traffic to Reduce Maintenance Needs

Some Division roads at Ware River are experiencing more traffic than they are capable of handling without environmental consequences. The Division intends to reduce use of its roads to a sustainable level, given current and anticipated maintenance staff and equipment levels. This can be accomplished through a variety of measures being considered during this next management period:

- Providing access to areas but not through-access can be accomplished by gating off roads in the middle, or leaving one end gated, creating dead-ends. In addition to reducing overall traffic, this practice may reduce illegal dumping.
- Terminating roads one or two hundred feet back from the water's edge allows the riparian area to recover while providing a better outdoor experience for visitors. Boulders are used to block motor vehicle access. This has already been accomplished in many locations along the major rivers.
- Temporary bridges and culverts installed for short-term access on Class 4 roads may be removed at the termination of the harvest, in order to discourage continued, unofficial use of these roads.
- Tops and slash generated during a timber harvest may be left in the Class 4 skidder and forwarder roads both during and after the harvest is completed. During the harvest, this practice buoys heavy equipment above the soil and reduces compaction. Following the harvest, the slash renders these paths impassable to recreational vehicles, and protects forest regeneration that will eventually return the road to a forested condition.

4.3.3.6 Long Pond Parking Lot

The Division proposes to reduce the Long Pond parking lot during this management period, although this project is a lower priority than upgrading drainage qualities on existing roads. This lot is currently approximately 2 acres in size, which greatly exceeds the needed capacity at the site. By reducing this lot to approximately 1 acre in size, and working to revegetate the remainder of the previous acreage, the Division intends to increase the buffer between the lot and the pond and provide better protection of associated water quality.

4.3.3.7 Bridges

There are six existing bridge structures on lands under the care and control of the Division. Three of these provide access to Class 1 roads. Whitehall Bridge is a concrete and steel structure that spans the spillway at Whitehall Pond by Rutland State Park. Maintenance responsibility rests with the DCR Division of State Parks and Recreation under the lease agreement for the park area. A co-maintenance agreement exists between DCR/DWSP and the Army Corps of Engineers at Barre Falls Dam for Chickering Bridge on Elm Street in Rutland and Morey Bridge on Brigham Road in Hubbardston. This agreement was reached because the Corps periodically inundates these structures. The Army Corps rebuilt Chickering Bridge in 1987. The steel girders were repaired and the decking was replaced with concrete. The Division rebuilt Morey Bridge in 1991. The stone abutments were rebuilt, a new wooden deck was installed, and the approaches were improved. However, this bridge has been shut down because of a failure in the stone abutments and is no longer available for vehicular use. Repairs would require a major reconstruction project, for which funding is not currently available. A fourth bridge spans the spillway at Comet Pond that accesses private cottages along the eastern shore. It was rebuilt by Division personnel in 2002.

The remaining two bridge sites service Class 3 roads. Historically, Rice Road Bridge spanned the Burnshirt and Twin Hill Road Bridge spanned the West Branch. Both could provide access to large sections of Division property. In each case the stone abutments appear to be in good shape, but the bridge structures are non-existent. If access to these areas for management purposes becomes a high priority, these bridges will need to be rebuilt with structures that can accommodate gravel trucks and fire equipment. The Rice Road span has been successfully crossed with a temporary bridge in the recent past to allow a timber harvest to proceed. Following the removal of the temporary bridge, however, both ATVs and horses have continued to use the area by crossing the river directly. Rebuilding a permanent bridge would bring this traffic out of the water and would allow better patrolling of the area. However, this would also require significant resources to upgrade the approaches and to complete the bridge.

At two other locations bridge structures are absent. These service Class 3 roads, but again also service large areas of Division property. A bridge at the crossing on Lackey Lane at the Burnshirt River in Barre could provide alternative management and patrolling access to a large wooded area on the north side of the Ware River. At Harris Lane where it intersects with the East Branch, a bridge structure could provide the only access to new acquisitions on the east side of the river.

Efforts to reconstruct these bridges during this management period are a lower priority than completing construction and maintenance of drainage structures and travel surfaces on the existing road network at Ware River. If resources remain following the completion of higher priority projects, Rice Road and Harris Lane Bridges are the first priority among the proposed bridge upgrades, because they provide the only access to large areas. The bridges at Twin Hill and Lackey Lane are secondary because they only improve access to the areas they service. Design and construction will necessitate the services of a licensed structural engineer and will require a service contract.

4.3.3.8 Considering Beaver Populations in Long-term Planning for Access

Beaver populations in the state (and throughout the Northeast) continue to increase as the number of trappers and amount of human-caused mortality remain low. There are at least 100 culverts within the Class 1, 2, and 3 roads at Ware River. A majority of these are round, small-diameter steel culverts. The

Division constantly deals with beaver plugging of road culverts. In some situations, the Division has successfully installed fences and water level control devices. These solutions, however, require continual maintenance and do not offer permanent relief. Further, fencing and/or water-level control devices may not be useful in all problem situations on the watershed. For example, in New York State in 1993, only 3% of sites were suitable for water-level control devices (Jensen et al., 1999). In situations where water level control devices are not an option, the Division removes beaver by either trapping or shooting individual animals. Although this solution may offer immediate relief, the habitat and conditions that attracted beaver initially have not been altered and these sites are often re-colonized within a short period of time. The Division recognizes the limitations of these various techniques and is working to develop a long-term plan for beaver management along roads.

Recent research suggests several management techniques to protect against beaver plugging of culverts. In 81% of sites examined in New York State, culvert size (area of inlet opening) was the major determinant of whether beaver plugged the pipe. The probability of a culvert being plugged increased with decreased culvert inlet opening area. Culverts with just 8 ft^2 of area were plugged 73% of the time, while culverts with 113 ft^2 of area were only plugged 7% of the time. Further, the design of the culvert was also an important determinant of whether beaver altered the site. Pipe-arch culverts were less prone to being plugged by beaver than round culverts. Round culverts are more likely to channel the water and reduce the stream width, alter flow rates, and generate noise that attracts beaver. Unplugged pipe-arch culverts tended to retain the natural stream width. The width of the stream at plugged culverts was twice that of the culvert inlet opening (Jensen et al., 1999).

Both research and general observations suggest that beaver are more likely to occupy sites with lower gradient and smaller width streams (e.g., first or second order), as well as abundant woody vegetation. In areas with flat topography, the total amount of woody vegetation was the primary predictor of beaver presence in New York State (Jensen et al., 1999). Because each site can be evaluated for potential beaver habitat and the probability of culvert plugging, the DCR/DWSP will incorporate beaver considerations in choosing stream crossing methods. In addition to evaluating watershed area, road classification, and stream size and gradient, DCR/DWSP personnel will also consider potential beaver habitat during replacement or installations of culverts. Culverts that may already be experiencing chronic beaver plugging will be prioritized for upgrading or replacement.

4.3.3.9 Management Guidelines for Beaver and Road Stream Crossings

DCR/DWSP will incorporate beaver management considerations into road and culvert planning when possible to reduce the probability of culverts being plugged by beavers. Recommended practices include the following:

- Where feasible and applicable, replace existing smaller culvert pipes with larger, oversized pipes.
- When possible, box or pipe-arch culverts should be used with a minimum inlet opening area of 18 ft^2. Smaller sizes are easily plugged.
- When sizing the culvert, it is important that the width of the culvert inlet is at least equal to or greater than the width of the stream. This will decrease noise and minimize the potential for altering flow.
- When installing culverts, avoid creating a depression or pond at the inlet as these are attractive to beaver.
- Installing multiple smaller pipes at a site instead of a larger pipe is not a workable alternative. Smaller pipes are much more likely to be plugged.

- In situations where beaver have a history of plugging even large culverts, other management options may be needed (see section 6.5.1.4.2).

4.3.4 Fire Protection

Except in periods of severe drought, wildfires do not pose a serious threat to the Central New England forest. Due to the high moisture content of forest stands, dead wood and other organic matter decompose quickly limiting the accumulation of fuels. Because of their fire resistance these forests are sometimes referred to as "asbestos forests." Human carelessness or arson causes the majority of fires, which most often occur during a narrow window in spring when dry grass and leaves warmed by intense sunshine become extremely flammable. These early spring fires burn quickly through the understory generally killing trees and shrubs <1" in diameter and can cause damage to larger trees resulting in the introduction of insect or disease. There is potential for limited short-term impacts where wildfires occur in close proximity to riparian systems. These same fast-moving spring fires induce germination of many plant species that quickly fill the gaps, stabilizing the soils and sequestering nutrients. Because of the limited acreage (average <10 acres/year on Division properties) most of these fires have little impact on the system's water quality.

In drought years, large scale uncontrolled wildfire can pose a serious threat to the protection values provided by the forest. Severe burns can consume the forest overstory, understory, and the organic soil layers, exposing the mineral soil below. The threat to water quality posed by larger fires is related to the scale of the burn and its proximity to water resource areas. In dry years, the cumulative effects of many small burns may also present a water quality threat, especially if these are concentrated on individual sub-watersheds. Potential impacts may include increases in overland flow, erosion, and nutrient loading. Where organic layers are destroyed by fire, these effects may be prolonged during the protracted recovery of vegetative cover on the burn site. In recent decades, fires have impacted only very small areas of DCR/DWSP watersheds. These fires ranged from light burns where only the understory was impacted to intense burns that killed mature trees, but all of these recent fires were rapidly controlled either naturally or through human intervention, and none imposed significant threats to water quality.

4.3.4.1 Policy

The following improvements in DCR/DWSP fire policy were implemented during recent years and have significantly enhanced the Division's ability to quickly suppress wildfires:

- Improved cooperation with local fire departments.
- Improved forest road conditions in areas of poor access and high fire hazard and risk.
- Improved training in fire suppression for DCR/DWSP staff.
- Implemented a fire watch during extreme fire situations.

A fire policy was established in 1987 and has been revised several times, most recently in January 1993. The policy outlines the procedures followed to notify personnel and the steps taken to suppress wildfires on Division lands. The fire policy, in conjunction with better coordination between DCR/DWSP, DCR/DSPR and local fire departments has improved fire response time and suppression efforts. This is attributable in part to the installation of a radio link with DCR/DSPR fire control personnel. The Division provides assistance to the local fire departments, and only assumes responsibility for suppression when directed by the local fire chief (usually for "mop up" operations, to extinguish embers remaining after the main burn has been suppressed). Improvements in fire suppression have been aided by the acquisition of new fire fighting apparatus and by improvements at the Ware River in gravel access roads and controlling public vehicle access through installation of security gates (which reduces the threat of ignition by recreational users).

Part of the fire policy includes provisions to close the watershed lands to all visitors under conditions of extreme fire danger. This measure will be taken during drought periods when the Division of Fire Control has rated fire risk as "Extreme" for five consecutive days.

4.3.4.2 Training

Timely and adequate response to the normal wildfire pattern on DCR/DWSP properties has been successfully provided by local firefighters, aided by DCR/DSPR and DCR/DWSP crews. However, the fire danger associated with severe drought is difficult to predict. On several occasions in the past decade the watersheds have been on the edge of serious drought conditions only to be relieved by major rain events. Nonetheless, dangerously dry periods are likely to occur in any given decade. In order to provide conservative protection for the water supply in the event that fire frequency throughout the region increases and outside crews become overwhelmed, there is a clear need to have an adequately trained and equipped wildfire fighting staff in-house, ready to deploy when needed.

Forest fire suppression techniques have not changed dramatically in the past 50 years. Western firefighters shovel and bulldoze dirt and employ aerial water and chemical attacks while eastern firefighters rely on ground delivered water as the dominant suppression tools. The ecological effect of suppression has been the subject of extensive debate in recent years. Many conservation organizations, including The Nature Conservancy have argued that fire suppression activities may exacerbate ecosystem degradation from wildfire. This degradation can occur by allowing the accumulation of fuels that eventually lead to much hotter fires than occurred historically, as well as through the direct impacts on the ecosystem resulting from fire suppression techniques. In conjunction with local fire departments and other state agencies, DCR/DWSP will continue to train personnel in alternative firefighting techniques that can minimize soil disturbance and the long term impacts on water resources. These may include more effective use of hand tools, environmentally friendly foaming agents, backfires, and the use of existing features such as roads and trails as firebreaks (rather than creating new breaks).

To participate on the DCR/DWSP fire crew, staff must have taken National Parks Service approved Wildfire Control Training and must have participated in a wildfire/controlled burn or attended approved training within the last two years. At present, twenty-three employees are certified and available to participate in fire suppression operations. A Fire Coordinator and assistant Fire Coordinator have been designated and they receive additional intensive fire control training.

4.3.4.3 Controlled Management Burns

Annually, DCR/DWSP staff participates in a number of controlled management burns on Division lands. Controlled management burns are deliberately ignited, controlled, and extinguished to burn over a designated area for a specific reason. These burns provide valuable training in equipment handling and in fire behavior, as well as a management tool to create or maintain desired habitat conditions that may be difficult to manage using other techniques. These burns have been used to maintain open non-forested habitat conditions, and may in the future be used to establish regeneration or control invasive plant species in forest stands.

4.3.4.4 Equipment

In the past ten years, the Division has made significant progress in properly equipping its fire control staff. New hose, floating pumps, a 250-gallon tank and pump fitted on the Division's logging skidder, and one 200-gallon and two 100-gallon slip-on tanks to mount on existing vehicles provide significant additional fire protection for the watersheds.

4.3.5 Transfers, Leases, and Agreements

In the mid 1950s the MDC transferred about 550 acres to the Army Corps of Engineers at Barre Falls for flood control purposes. The transfer consisted of two nearly equal parcels, one containing the main dam and the other containing the dike area. In addition, the Corps acquired a flooding easement on about 1,800 acres. In the early 1960s the MDC sold several hundred acres to the City of Fitchburg in the northeast section of Hubbardston for the development of a municipal water supply. This included land on Bickford Pond and the area now flooded by Mare Meadow Reservoir. In 1961, the MDC leased 1,300 acres to the Department of Environmental Management to develop a recreation facility at Whitehall and Long Ponds (Rutland State Park). The lease expired in 1986 and was renewed for 230 acres adjacent to the bathing area. The Division has entered into an agreement with the Division of Fisheries and Wildlife that permits DFW to post approximately 5,000 acres as wildlife management areas. These are located at the former Cunningham Estate and around Barre Falls Dam.

4.3.6 Rights-of-Way

Requests for new or revised Rights-of-Way (ROW) are primarily received from electric power companies, railroads, telephone companies, and town utilities. Requests are considered on a case-by-case basis. The primary consideration of the review is to prevent adverse environmental impacts to any watershed resource. The applicant must agree to follow all applicable regulations and specific terms and conditions proposed by the Division before the ROW is approved and any construction is permitted to proceed.

Maintenance of utility and railroad rights-of-ways follows procedures for resource identification and notification established in a 1997 document entitled: *Memorandum of Understanding between the Massachusetts Department of Food and Agriculture, Pesticide Bureau and the Metropolitan District Commission, Division of Watershed Management, on: Identification of Water Features within the Quabbin, Ware and Wachusett Watersheds, which are subject to protection under DFA Pesticide Regulations 333 CMR 11.00.* As these rules are updated and revised, Division staff will implement any changes that may be promulgated by the Department of Food and Agriculture.

4.3.7 Land Disposition Policy

The Division regularly comes under pressure from both private and municipal parties for disposition of Division lands for purposes that may be inconsistent with drinking water supply protection. While there are certain areas of land ownership throughout the water supply system that may not be of critical importance to water supply protection, these areas require careful scrutiny prior to disposition. The Division will consider land disposition only under exceptional circumstances. The DCR/DWSP Land Disposition Policy, approved in April, 1998, provides a framework for the agency to properly discharge its obligations to protect the water supply and to protect the Commonwealth’s broader interests in open space protection under Article 97 of the Constitution of the Commonwealth. The intent of the Watershed Land Disposition Policy is to provide additional watershed-specific instructions to the Executive Office of Environmental Affairs on disposition of Article 97 lands.

4.4 Land Acquisition

The three active Division watersheds have been included in the land acquisition program since its inception in 1985. While a preponderance of the available acquisition resources have been used to acquire acreage on the Wachusett Reservoir watershed (highest priority), sensitive lands have also been protected on the Quabbin Reservoir and Ware River watersheds. The purpose of the land acquisition program is to acquire sensitive watershed land and to protect it from urbanization and then to restore and/or maintain stable forest cover on this land. Few sites already developed or significantly disturbed are acquired. Instead, relatively undisturbed lands are purchased as a preventative measure, countering potential threats to water quality that would result from development of these lands.

To help determine which parcels would provide the greatest water quality protection for the money spent, MDC/DWM developed land acquisition models, first for the Wachusett and then, in 1998, the Ware River watershed. The Ware River model was developed by MDC and MWRA staff with help from the Department of Natural Resources Conservation at the University of Massachusetts, Amherst. The model, employing 12 weighted criteria, addresses the “varying source” assumptions incorporated in modern hydrologic models. Land in and around tributaries, aquifers, and wetlands will contain the greatest proportion of a basin’s water at any given time. Studies of small New England watersheds emphasize the importance of low lying, water-rich areas in contributing the majority of runoff during storm events through saturated surface and subsurface flow (Dunne and Leopold, 1978, and Hewlett and Nutter, 1969). As a precipitation event continues, the area contributing to saturated flow increases. It is believed that this “variable source,” however severe the storm event, includes less than half the watershed area. Pollutants introduced to these water-rich sources are more likely to impact tributary water quality than those introduced on non-source areas.

The Ware River model objectives were: a) to develop a land parcel prioritization ranking to protect water quality; b) to develop a method to evaluate relative time-of-travel distribution on a landscape; and c) to identify locations in the watershed that are most sensitive to water quality degradation. The model applies a number of watershed protection criteria to generate a relative sensitivity measure for any given parcel. The model shows that low priority areas (i.e., low sensitivity areas) cover the highest percentage of the watershed. The more watershed protection criteria that apply to any given area (i.e., high sensitivity areas), the lower the percentage of the watershed represented. By focusing land acquisition resources on these highly sensitive acreages, maximum benefits are achieved with respect to water quality.

Since 1985, the Commonwealth has acquired, 3,255 acres (2,715 in fee & 540 in conservation restrictions) for watershed protection on the Ware River watershed, bringing the total holdings to 23,694 acres (including 787 acres of CRs), or 38.2% (up from 31.3% in 1985) of the watershed. Expenditures for this acreage total $12.3 million. Funding for the watershed land acquisition program has come from the 1983 Open Space Bond ($3 million), the 1987 Open Space Bond ($30 million), and the Watershed Protection Act of 1992 ($135 million). Approximately $15 million remains available for land purchases ($3 million per year through 2008) within the watershed system. Most of these funds will be spent purchasing land on the Wachusett watershed, which is the least protected basin, with 26% under Division control. Efforts will continue toward purchasing a number of previously identified key parcels throughout the Quabbin Reservoir and Ware River watersheds. Ware River subwatersheds were prioritized by the Land Acquisition Policy Panel (LAPP) as part of the model development work. Based on proximity to the intake and suspected travel time parameters, the order of priority for land acquisition in the major Ware River subwatersheds are:

1. Parkers Brook (mostly Division controlled – very few acquisition opportunities).
2. Burnshirt and Canesto Rivers, and Natty Pond Brook;.
3. East and West Branch Ware River above the Army Corps dam.
4. Mare Meadow.

Accordingly, the decision was made to concentrate most future Ware River watershed land acquisition efforts on the Burnshirt and Canesto River subwatersheds, as well as Natty Pond Brook subwatersheds.

4.5 Protection of Privately-Owned and Community-Owned Land

4.5.1 Conservation Restrictions

Acquiring conservation restrictions from watershed landowners is another form of land protection utilized by the Division. Conservation restrictions constitute a partial acquisition of rights to land ownership, usually in the form of development restrictions. In these cases, the Division agrees to acquire limited rights to property and to record these rights as an attachment to a landowner's deed. The landowner remains the owner and retains all rights to ownership except those described in the easement. This is a "less than fee" acquisition.

Conservation restrictions (CRs) are the preferred method of land protection because:

- Some landowners prefer to continue owning their properties despite agreeing to restrict its use.
- Landowners remain owners of record and continue to pay property taxes directly to the town which eliminates the obligation for the Commonwealth to make payments-in-lieu-of-taxes.
- The land is given equal value to fee acquisitions as protected open space.
- The costs of protecting the land are less than fee acquisitions.
- The costs of managing the lands as fee holdings are eliminated (though an annual CR monitoring inspection is required).

Of paramount importance to the Division is the protection of water quality. Any easement acquired by the Commonwealth for watershed protection must help insure the maintenance of a pure public drinking water supply. To this end, it is the policy of this agency to expend funds for the purchase of conservation easements only on acreage with uses, both present and projected, that do not conflict with this goal. Land uses and practices expressly excluded from consideration for easement purchases include:

- Dwellings
- Septic systems and leach fields
- Storage, stockpiling, or use of hazardous materials, petroleum products
- Pesticides and herbicides, manure and fertilizers
- Livestock
- Tillage
- Excavation of gravel, loam, peat, and/or rock except as incidental to land maintenance

- Use by the general public of horses or motorized all-terrain vehicles including snowmobiles, 4WD recreational vehicles, and motorcycles (Division assistance with gates and signs to limit access may be available upon request)
- Timber harvesting or tree cutting not in compliance with the Massachusetts Forest Cutting Practices Act (MGL ch. 132) and Division Conservation Management Practices for forest management
- Use of conservation restriction land to satisfy any zoning requirements on adjoining unrestricted property
- Construction of any new roadway for purposes of accessing unrestricted land for development purposes
- Any subdivision of conservation restriction land without Division approval
- Any other uses considered by DCR/DWSP to be detrimental to watershed protection

Continued use of the property by its owners for forestry, wildlife, recreation, and privacy purposes is encouraged. Conservation easements do not require owners to make their land accessible to the public, but the Division reserves the right to periodically enter the property to inspect for continued compliance.

After a property has been acquired a baseline study is conducted by the Division with the landowner to get a land use history of the property and to photo document the land as it is at the time of the purchase. Conservation restrictions are then monitored once a year to ensure compliance with the Order of Taking. Boundary tags may be put up on the conservation restriction to help determine the CR boundary and to help discourage abutters from encroachment.

4.5.2 Payments In Lieu of Taxes (PILOT)

After land is acquired for watershed protection, the DCR/DWSP is required by MGL ch. 59, s5G to make Payments In Lieu of Taxes (PILOT) on these properties. This law took effect for Ware River watershed lands in 1987. The PILOT amount is calculated by multiplying the local commercial tax rate by the land valuation as determined by the Department of Revenue (DOR). While the program is administered by the DCR/DWSP, the PILOT funds come from the MWRA. The DOR is required to value the land at its "highest and best" use; this means that property that is under Article 97 open space protection is still valued as developable parcels. A key provision of this statute is that the PILOT amount can never be less than the previous year's amount, even if the tax rate or valuation diminishes. In FY2003, PILOT distributed $731,734 to Ware River watershed communities as follows:

Community	PILOT FY2003
Barre	$129,668
Hubbardston	$238,371
Oakham	$77,760
Rutland	$285,401
Templeton	$534
Total PILOT Ware River Watershed	$731,734

Revaluation of state property occurs, by law, only once every five years. Unfortunately for the communities, this means that any property acquired within this cycle will not be included in determining PILOT amounts. However, the Division does pay the remainder of the existing year's taxes at the time of acquisition, and if the sale occurs in the second half of the fiscal year, it is obligated to pay the following year's taxes as well. Furthermore, if a property is being purchased out of Chapter 61 or 61A (the Forestland Taxation program), the agency is required to pay "rollback" taxes to the town, rebating the previous four years' tax abatements.

The state lands revaluation by the Department of Revenue that concluded in June of 2000 placed the value of Division property in Ware River watershed communities at $51 million, which is more than 80% greater than the 1995 valuation. This increase, which took effect with the FY2001 PILOT, reflects both the additions in Division land ownership (particularly of valuable "prime lots" that could have been developed) and the rise in property values throughout the watershed. Starting in FY2001, the PILOT program will annually distribute a minimum of approximately $725,000 to the Ware River watershed communities.

Community	DOR Property Valuation FY2000	DOR Property Valuation FY2001	% Property Value Increase	PILOT FY2000	PILOT FY2001	%PILOT Increase
Barre	$4,599,595	$9,315,200	103%	$105,565	$129,668	23%
Hubbardston	$7,247,618	$16,798,500	132%	$118,933	$238,371	100%
Oakham	$5,161,383	$5,775,100	12%	$70,467	$76,982	9%
Rutland	$10,470,439	$18,814,300	80%	$142,922	$277,135	94%
Templeton	$32,185	$28,600	-11%	$469	$469	0%
Total Ware River Watershed	$27,511,220	$50,731,700	84%	$438,356	$722,625	65%

The PILOT program provides a significant benefit to the Ware River watershed communities. They receive the same revenue from permanently protected open space that they would have received from developable land, without the associated municipal costs of police, school and fire services. DCR/DWSP will continue to implement the PILOT statute, work with the MWRA to ensure proper payments, and assist the DOR in its revaluation efforts.

4.5.3 Technical Assistance to Communities

The Division recognizes the unique "home rule" land use authority vested in Massachusetts municipalities. Most of the specific planning and regulatory tools and techniques that comprise watershed protection (for areas outside direct Division jurisdiction) must be adopted at the municipal level through town meetings, and enforced by local volunteer boards. To improve local programs for water protection, the Division adopted the role of advocate and advisor. The Division's Community Technical Assistance work is aimed at a single goal: to use and improve the watershed protection afforded by local land use control programs.

In working with watershed area officials and citizens, the Division tries to find common ground on resource protection issues. The Division stresses that combined efforts help both local resources and the metropolitan Boston water supply. The technical assistance programs emphasize local source protection and its immediate impact on watershed residents and decision-makers. Through a cooperative approach, the Division improves land-use planning, control of development, and general environmental protection at the local level. There are three main avenues through which the Division provides municipal technical assistance:

Meet regularly with local boards. On a monthly or as-needed basis, Division staff has attended regular meetings of local boards, such as the planning board, board of health, and conservation commission.

Provide direct technical assistance support to local boards and community organizations. Upon request from communities, through regular contact at board meetings and/or through regulatory review process, the Division offers professional expertise and Division resources (e.g., project review, contract development, and GIS maps). This type of in-house technical assistance is intended for small projects, whereas large or complex requests would be recommended for outside consultation, with Division support if possible (see next item, DWSP grant program).

Provide funds through a competitive grant program. In order to strengthen local planning capability, the Division provides funds, when available, to help watershed communities develop and implement comprehensive planning projects. $150,000 has been distributed to Ware River towns since this program was initiated with the passage of the Watershed Protection Act in 1992. A competitive application process was instituted in FY2002 to help evenly distribute these funds, when available, throughout the Watershed System. A $25,000 contract was awarded to Rutland through this program.

4.5.4 Technical Assistance to Private Forest Landowners

The Division started a program in 1995 to provide direct technical assistance to forest landowners at the Wachusett Reservoir watershed, where nearly 50,000 acres of unprotected forest lands existed. The Division hired a Private Lands Forester, with funding provided jointly by MDC and the USDA Forest Service. This forester assisted DEM foresters in administering MGL ch.132 (the Forest Cutting Practices Act) on the Wachusett Reservoir watershed. In order to increase landowner participation in Chapter 61 and the Stewardship programs, the Division contracted to hire private consultant foresters to complete forest management plans for landowners wishing to gain entry into these programs. In FY 95, $40,000 was dedicated to completing plans for approximately 2,000 acres of private forestland and to cost-share practices that benefit the watershed, such as tree planting and erosion control on roads. The Private Lands Forester worked closely with the Land Acquisition Coordinator so that lands that should be added to acquisition lists (due to imminent development, etc.) could be more easily identified. The Land Acquisition Coordinator also directed landowners with a strong aversion to selling their land to the Private Lands Forester, so that intermediate protection measures (Ch 61 or Stewardship) could be utilized.

At the conclusion of the contract for a full-time Private Lands Forester, the Division shifted responsibilities for maintaining the private lands stewardship program to the staff in the Natural Resources Section. The program has continued with additional Division funding and as of July, 2003, 64 properties totaling 4,556 acres had completed 10-year land management plans. Thirteen of these completed properties are located within the Ware River watershed, totaling 803 acres. The average cost to the Division to provide this protection through private land management plans is approximately $12 per acre.

5 Management of Forested Lands Controlled by DCR/DWSP

5.1 History of Land Management on the Ware River Watershed: 1927-1980

The majority of the present Division holdings on the Ware River watershed was purchased between 1927 and 1940, for drinking water supply protection. At the time of purchase, land use/land cover in the area was a combination of active agricultural land, abandoned fields, and forest land. The removal of most structures from the purchased land was completed by 1932, and the labor force was directed to plant the open agricultural lands to softwood species. This was undertaken primarily because it was believed at the time that forest growth helped regulate flooding and was essential to maintain water production and protect water quality. Approximately 1,700 acres were planted to white, red, and Scotch pine, Norway and white spruce, and European larch between 1931 and 1945. The major portion of this acreage was planted with red pine, with lesser amounts of the other species. Some areas were planted with combinations of these species. Red pine was chosen because it is less susceptible to white pine blister rust and white pine weevil, because it was easier to propagate in the nurseries, and because it grows rapidly and is somewhat self-pruning. In plantations where red pine was interplanted with other species it generally expressed dominance and out-competed these other species.

During the 1940s, the MDC, in conjunction with the U.S. Department of Agriculture, undertook a program to eradicate white pine blister rust. A crew was assigned to remove all currant and gooseberry bushes within the watershed, which serve as alternate hosts for blister rust. Due to these efforts and natural controls, blister rust is a very minor problem on the watersheds today.

The first harvest operations conducted on Division-controlled lands were salvage operations of timber damaged by the hurricane of 1938. From field observations, this salvage work was extensive, but only a portion of the vast amount of damaged timber was removed. Following these salvage harvests, the first silvicultural operations began in the late 1950s. Low thinnings were conducted in a number of red pine plantations to improve growth and quality.

Continuous Forest Inventory (CFI) plots were established at the Ware River watershed in 1962 by MDC Forest and Park Supervisor Fred Hunt, who established the first CFI plots at Quabbin Reservoir in 1960. Bruce Spencer replaced Fred Hunt in 1965 and became the first MDC Chief Forester. While spending much of his time on the Quabbin watershed, the Chief Forester initiated removal of the abundant low-quality white pine at the Ware River. Management activities gradually intensified, with a continued emphasis on the removal of low quality, second growth white pine stands. Ten timber sales were marked and sold in the 1960s. Approximately 2.75 million board feet of timber were sold, producing revenues of about $57,000.

Jim Joslin worked from 1969-72 as the first full time MDC Forester for the Ware River watershed. He oversaw the completion of a forest type map during this period, used to prioritize management operations. This type or stand map located the expansive acreage of low quality pine stands that are also apparent in the CFI data. Chuck Walker, hired part-time as the next Ware River forester, continued stand improvement work from 1972-1977.

DWSP's watershed lands on the Ware River presented an enormous forest management challenge that was not adequately addressed until the MDC hired Stephen Drawbridge in 1978 to fill the function of the Ware River Forester. From this time to the present, several thousand acres of low quality pasture pine stands were treated. These were either regenerated to mixed oak/pine and oak/hardwood stands, via overstory removal cuts, or left as pine stands but improved by cutting the least vigorous or most poorly-formed trees. These harvest cuts did not produce large amounts of revenue, but the improved vigor, increased oak component, and greater age and species diversity have collectively made the watershed forest more resistant to and resilient following natural disturbances. During the 1970s, twenty-nine timber and cordwood sales were marked amounting to 2.55 million board feet and 1,500 cords of fuelwood and providing $100,000 in revenue.

Ware River Field Headquarters

5.2 First Ware River Land Management Plan: 1980-2000

The first formal forest management plan for the Ware River was written by Stephen Drawbridge in 1983. Due to concerns over water quantity at that time, the plan focused on water yield more than this current plan. Between 1983 and 2000, slightly more than 3,000 acres were treated. About 2,300 acres received some type of partial cut. These included intermediate thinnings, first or second removal cuts in the shelterwood regeneration system, or extended shelterwood removal cuts in areas that include filter and buffer areas along wetlands and waterways.

770 acres were regenerated during the same time period. Most of this regeneration cutting was final removal cuts using the shelterwood regeneration system and included stands where some portion of the residual stand was retained (shelterwood with reserves or green retention). About 75 acres were clear cut (overstory removed in a single cutting regardless of the presence of advance regeneration) in 15 separate parcels averaging about 5 acres apiece. Most of the openings were between one and five acres with about half of the acreage coming from a single area. These silvicultural operations yielded 8.4 million board feet of lumber, 9,971 cords of fuelwood, and approximately 15,000 tons of softwood pulp from 1983 to 2000. The sale of this material grossed approximately $750,000 for the Commonwealth.

Forest composition was affected in a small, but positive way. A large percentage of the forest cover on the Ware River watershed is dominated by softwoods. Sixty-eight percent of the total volume removed during the last management period was white pine. Natural stands dominated by white pine accounted for sixty-two percent of the area regenerated, and softwood plantations accounted for another twenty-two percent. Regenerated areas contain more diverse species mixtures than the stands they replaced. Compositional variation in regenerated areas is largely determined by the cutting regime used. Most regeneration on Division properties at Ware River includes more hardwood than the stand that was regenerated, and shade intolerant species such as gray birch and poplar are common where light levels are high. There are also exceptional examples of red oak regeneration, one of the more difficult silvicultural challenges. While the effort of the period from 1983 to the present was a good start toward improving the overall vigor and quality of the Ware River forest under Division control, many stands still contain low quality white pine originating from field abandonment. Addressing these stands will remain challenging for managers in this next management period.

As a result of these past silvicultural practices, watershed protection improved during the previous management period. Many softwood plantations and low quality white pine stands were replaced with complex mixtures of hardwood and softwood, increasing species diversity and improving species-site relationships. The regeneration of 770 acres improved structural diversity across the forest, and therefore improved forest resistance and resilience. Intermediate thinnings improved forest vigor by providing increased light and growing space to residual trees.

5.3 Current Forest Conditions on the Ware River Watershed

In general, the current forest on Division lands on the Ware River watershed is made up of a range of low to high quality stands, both managed and unmanaged, with an abundance of forest regeneration. A large portion of the upland forest occurs on dry outwash and dry washed till soils, which are less productive than moist till soils, but also somewhat less sensitive to logging equipment. Some of the most productive sites are still occupied by low quality stands that developed after pastureland was abandoned.

Nearly all of the uplands controlled by the Division on the Ware River watershed are forested (99%), with the remainder in field. Ninety-four percent of the forest is more than sixty years old, and sixty percent is over eighty years old. Some older stands also have an age class that originated with the hurricane of 1938, making them two-aged. A small portion of the forest area is comprised of plantations, established by MDC personnel in the 1930s and 1940s. White, red, and Scotch pine, Norway and white spruce, and European larch were planted as monocultures or in various mixtures. Most of these plantations have been converted to open land or regenerated to natural stands. The remaining forest originated from past land use and natural disturbance. The largest portion of the forest originated from agricultural lands abandoned in the late 1800s and early 1900s. These developed as understocked white pine stands (“old field white pine”) that matured into low quality mixtures of pine and hardwood. Again, most are even-aged stands, but in some there is a remnant of trees that were present in the original pasture or trees that regenerated following the 1938 hurricane, giving them a two-aged or multi-aged structure.

5.4 Continuous Forest Inventory 1979-1999

Continuous Forest Inventory (CFI) plots were established throughout Division lands on the Ware River watershed in 1962. These are one-fifth acre (~53' radius) permanent plots located at the intersections of a half-mile grid (each represents 160 acres). The plots are remeasured every 10 years. CFI plots were remeasured on the Ware River in 1979, 1989 and 1999, and are summarized here. New plots are added as land is acquired and plots that have been converted to treeless wetlands are eliminated.

Every tree greater than 5.5" in diameter at breast height (DBH) on each plot is numbered and measured for DBH and total height, and given a forest product rating (e.g., sawlog, fuelwood, wildlife tree). This product classification is a standard CFI entry, which indirectly serves as a ranking of the tree's vigor. Plots are not managed differently than the area in which they fall; if that area receives silvicultural treatment, the plot receives the same. Records are kept to distinguish trees that have been cut from those that died.

Data from CFI plots is most useful for following changes in growth and mortality rates. Health and vigor of the forest over time can also be assessed from CFI information. Basal area, the cross-sectional area of a tree stem at breast height (4.5 feet) is calculated from diameter measured at the same height (DBH). The average basal area growth for Ware River CFI plots measured in 1989 and 1999 was 1.57 square feet/acre/year. In 1999 the average diameter at breast height was less than 9.6’ on 19% of the plots, between 9.6” and 15.5” on 79% of the plots, and over 15.5” on 2% of the plots. Average annual diameter growth rates for major species during the 1979-1989 and 1989-1999 periods are listed in Table 4 below (calculated only from live trees measured at the beginning and end of each decade.)

TABLE 4: DIAMETER GROWTH RATES FOR TREES ON CONTINUOUS FOREST INVENTORY PLOTS

Species	Annual Diameter Growth (inches) 1979-1989	Annual Diameter Growth (inches) 1989-1999
White pine	0.14	0.11
Red pine	0.19	0.08
Hemlock	0.14	0.12
Red oak	0.17	0.15
Black oak	0.11	0.11
White oak	0.09	0.07
Scarlet oak	0.14	0.12
Sugar maple	0.11	0.08
Red maple	0.11	0.08
Black birch	0.07	0.11
White birch	0.07	0.07
White ash	0.18	0.14
Hickory	0.08	0.04
Black cherry	0.10	0.06

The biggest change in diameter growth rates occurred in red pine. Many of the plots containing red pine have been recently harvested, so that most of the trees measured in 1989 were harvested and therefore not included in this calculation. The growth rates for most species stayed about the same or went down slightly. This may be due to the increased age of the forest. All else being equal, periodic annual diameter increment accelerates in the early years of stand development, and then declines as a forest matures.

Species distribution was calculated in 1999 from CFI plots based on 4,151 measured trees and the percent of total basal area on all plots represented by each species (Table 5). Changes result from a combination of growth, harvest, mortality, and new plots. Approximately 67% of the total basal area has steadily been composed of white pine and oaks, with more pine overall. Maples account for 16% and hemlock 6.5%. Black cherry is the most prominent of all other species, and has decreased slightly from 4.2% in 1979 to 3.7% in 1989 and to 3.5% in 1999.

Regeneration of a Pine Plantation

During the most recently measured decade (1989-1999), approximately 9% of the total basal area was harvested, while an additional 5% was lost to natural mortality. From 1979 to 1999, major softwood species declined from 52% to 46% with corresponding gains in major hardwood species. This is primarily the result of an effort to reduce the amount of pasture and plantation pine. Approximately 68% of the 1979 basal area of red pine was cut before 1989, and 30% of the remainder was cut between 1989 and 1999.

TABLE 5: CHANGES IN SPECIES COMPOSITION ON WARE RIVER CFI PLOTS, 1989 TO 1999

SPECIES	BA 1989	% of 1989 Total BA	Cut	% Cut	Died	% Died	1989 BA of Trees Alive in 89 and 99	1999 BA of Trees Alive in 89 and 99	89 to 99 Growth of Alive Trees	Growth as % of 89 Net BA	Ingrowth	Ingrowth as % of 89 Net BA	1999 Total Basal Area	% of Grand total 1999 BA	Net change in BA	Net change as % of 1989 BA
White pine	872	39%	100	11%	34	4%	738	887	149	20%	29	4%	916	37%	44	5%
Hemlock	114	5%	0	0%	0	0%	114	141	27	24%	21	18%	162	7%	48	42%
Red pine	24	1%	7	30%	1	5%	16	18	2	14%	0	0%	18	1%	-6	-25%
Norway spruce	36	2%	0	1%	2	5%	34	41	7	22%	0	0%	41	2%	5	15%
Other softwoods	13	1%	0	0%	5	38%	9	9	0	0%	0	0%	9	0%	-4	-31%
Sugar maple	11	0%	0	3%	1	6%	10	12	2	19%	1	11%	13	1%	2	19%
Red maple	365	16%	33	9%	28	8%	304	365	61	20%	28	9%	393	16%	28	8%
Red oak	301	13%	27	9%	7	2%	267	337	70	26%	7	3%	345	14%	44	14%
Black oak	37	2%	3	8%	1	1%	33	39	6	18%	1	3%	40	2%	3	10%
Scarlet oak	165	7%	12	7%	4	3%	149	190	41	27%	3	2%	193	8%	28	17%
White oak	152	7%	13	8%	6	4%	134	155	20	15%	3	2%	158	6%	5	4%
Yellow birch	10	0%	0	0%	0	0%	10	12	2	23%	3	36%	15	1%	6	59%
White birch	12	1%	1	7%	2	21%	8	10	1	18%	0	0%	10	0%	-2	-15%
White ash	16	1%	1	7%	2	14%	12	16	4	29%	2	17%	18	1%	2	15%
Hickory	11	0%	0	5%	0	2%	10	11	1	12%	2	15%	13	1%	2	19%
Poplar	11	0%	0	3%	5	44%	6	8	2	34%	1	25%	9	0%	-2	-15%
Black cherry	85	4%	7	8%	7	8%	72	83	11	15%	4	6%	87	4%	2	2%
Other hardwoods	14	1%	0	0%	3	21%	11	12	1	9%	3	27%	15	1%	1	7%
Totals	2,249	100%	205	9%	107	5%	1,938	2,346	408	21%	110	6%	2,456	100%	207	9%

5.5 DCR/DWSP Goals for Forest Management on the Ware River Watershed

In developing land management goals for the Ware River watershed, the Division considers the status of this water supply relative to other watersheds. While the Ware River is administered as part of the Quabbin Section, it has some unique features that affect these goals. It is a river diversion system that, when activated, utilizes high flows during a nine month period to supplement reservoir volumes. Water from the Ware River is diverted to the Quabbin reservoir through Shaft 11A, which by design forces a very long travel time through the reservoir before this water reaches the aqueduct intake at Shaft 12. The absence of a reservoir, limited periodic use of the water, and a prolonged time separation from the consumer has brought about a modified land management history, including the accommodation of limited secondary uses on the Ware River watershed. However, the status of the Ware River as part of the supply system has not changed. The Division continues to choose forest management options that are efficient and provide excellent water supply protection, while also addressing secondary goals for wildlife habitat and biodiversity to a somewhat greater extent than on other Division watersheds.

MGL Chapter 737, Acts of 1972 provides directions for the "conservation and regulation" of Division lands on the Quabbin and Ware River watersheds. Sections 2 and 8 of this act say:

> The natural ecology of the district shall be maintained, and it shall be conserved in its present degree of wilderness character and shall be protected in its flora and fauna in all reasonable ways to assure the balanced wildlife habitat…the commission shall make…rules and regulations…to conserve the wilderness, watershed and reservoir character of the district.
>
> Lumbering or logging operations shall be permitted within the district to the extent and for the purpose of maintaining and conserving its forests in a healthful state of natural ecological balance consistent with reservoir and watershed purposes, but such lumbering and logging operations shall not be of a tree farming nature, so called, wherein natural diversification of tree species is upset nor wherein wildlife habitat or food chain growth is adversely affected.

MGL Chapter 372, Acts of 1984, which created the Massachusetts Water Resources Authority, also created the MDC Division of Watershed Management with the principal mandate, in Section 105, to "utilize and conserve said water and other natural resources in order to protect, preserve and enhance the environment of the commonwealth and to assure the availability of pure water for future generations."

The Division interprets these legislative mandates to require the maintenance of a forest cover on the vast majority of its holdings. Because of the strong tendency of the land to return to forest if abandoned, forest cover is undoubtedly the only practical cover for large holdings in this landscape. Furthermore, Division properties provide an opportunity to maintain or increase watershed forest cover to counteract losses of forest associated with development. The question left to Division forest managers is to determine what form of forest cover best meets the Division's goals. Through a combination of research and decades of experience managing these watershed forests, the Division is continually refining the design of a watershed protection forest that best addresses its mandates.

For the period covered by this plan, the principal goals for the management of Division properties on the Ware River watershed are to:

- PROVIDE A VIGOROUS FOREST COVER, DIVERSE IN SPECIES COMPOSITION AND TREE SIZES AND AGES, AND THEREFORE ABLE TO RESIST AND RECOVER FROM DISTURBANCE AND TO RETAIN AVAILABLE NUTRIENTS.

- MAINTAIN THE ABILITY OF THE FOREST TO REGENERATE FOLLOWING DISTURBANCE.
- PREVENT EROSION OF SEDIMENTS AND NUTRIENTS FROM THE WATERSHED FOREST THROUGH CAREFULLY APPLIED CONSERVATION MANAGEMENT PRACTICES.
- PROVIDE LONG-TERM WATER QUALITY PROTECTION WITH MINIMAL INTERVENTION BY DEVELOPING A VIGOROUS, LOW-MAINTENANCE FOREST.
- COMPLY WITH OR EXCEED ALL ENVIRONMENTAL REGULATIONS GOVERNING FOREST MANAGEMENT ACTIVITIES AND WATER RESOURCES PROTECTION ON DIVISION WATERSHED PROPERTIES.
- APPLY FOREST MANAGEMENT PRACTICES THAT MAINTAIN CURRENT WATER YIELDS FROM THE WATERSHED.
- WITHOUT COMPROMISING PRIMARY GOALS FOR WATER QUALITY PROTECTION, PROMOTE THE SECONDARY GOALS OF IMPROVING THE GROWTH AND QUALITY OF THE FOREST RESOURCE, PROTECTING AND ENHANCING HABITAT FOR NATIVE WILDLIFE SPECIES, AND MAINTAINING AND ENHANCING BIOLOGICAL DIVERSITY.

Diverse forest cover

The Division has determined that for watershed protection purposes, a diverse, vigorous forest cover should be maintained on the vast majority of its holdings. The forest overstory provides temperature regulation for surface, ground, and stream waters, and provides seed to regenerate the forest following disturbance. Those portions of the forest that are actively growing and assimilating available nutrients limit the export of these nutrients to the water supply. The forest understory provides uninterrupted recovery from overstory losses. The forest overstory, the forest understory, the vegetative ground cover, the thick organic mat of decomposing matter on the forest floor, and root systems interspersed within the mineral soil below all work in concert to regulate water yield and to produce high quality water.

It is a Division goal to protect the ability of the forest cover to regenerate itself, so that it is capable of quickly recovering from disturbance. While hurricanes are potentially the most disruptive disturbance facing the Ware River watershed forest, the more frequent occurrence of other disturbances is also of concern to managers. These include the effects of insects and diseases and changes brought about by smaller scale weather events, such as localized windstorms and heavy snow or ice storms. The New England forest very aggressively regenerates following most disturbances. The major exception is in areas where browsing of the young seedlings is excessive, generally due to exceptionally high numbers of deer or other herbivores. The forest's ability to recover rapidly from disturbances will be maintained by controlling the impacts of these herbivores.

Producing and retaining a diverse forest cover addresses the Division goal to protect the water supply from undesirable chemical, nutrient, and sediment inputs in a variety of ways. First, this cover reduces the erosion potential of precipitation and minimizes overland flow. It also serves to buffer chemical impacts to water quality by maximizing water contact time with vegetation and soil components. Through the process of evapotranspiration, forests act as water yield "regulators," moderating the potential water yields of watersheds and thereby controlling the associated transport of nutrients to the water supply. Finally, forests that are actively growing are also assimilating nutrients to accumulate biomass, further reducing nutrient export to tributaries.

5.6 Current DCR/DWSP Forest Management Objectives on the Ware River Watershed

An effective forest management plan functions at many levels. Landscape, forest, and stand level objectives are pursued over various planning periods that can range from one to a hundred years and more. The levels of biotic organization, and therefore of natural resource management planning, are interdependent and hierarchical – one building on the next. Objectives at the landscape level are achieved by planning at the forest level and by acting at the stand level. Integrating objectives at various organizational levels is an essential step in planning.

The primary objective of DWSP forest management on the Ware River watershed is to conduct silviculture that develops and maintains a forest cover that best supports the production of high quality drinking water. This watershed protection forest is vigorous, diverse in species and ages, actively accumulating biomass, and actively regenerating. Because the Division's primary forest management objective is water quality protection, silvicultural treatments are designed to create and maintain vigorous forest cover that both resists and recovers from a wide range of disturbances. Improving the structure and composition of stands will reduce their susceptibility to disease, insects, and disturbance, creating a low-maintenance, persistent forest cover. In the present management period (2003-2012), treatments are planned to:

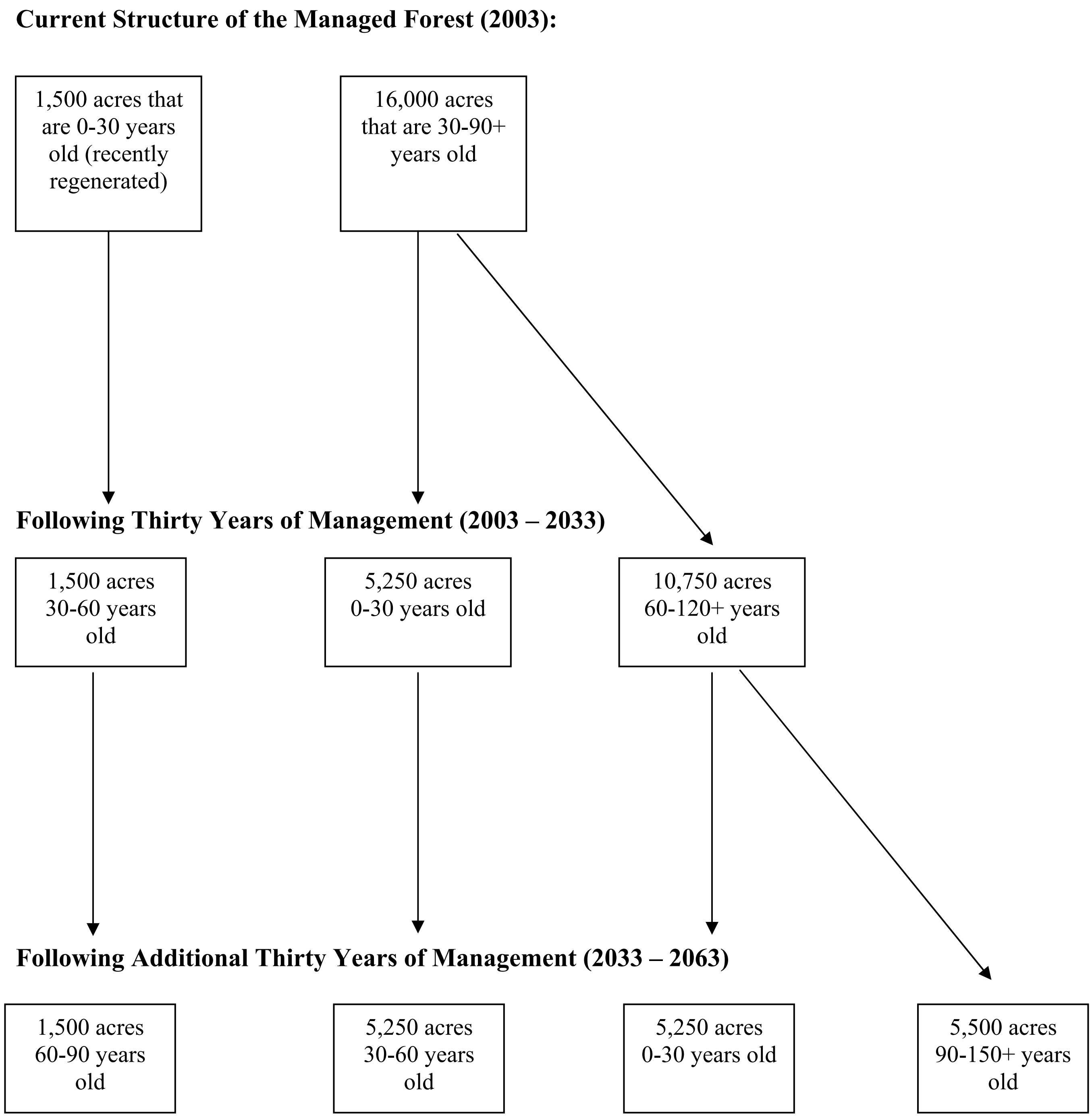
- Increase the structural diversity of the forest
- Establish regeneration as necessary, and release advance regeneration
- Regenerate approximately 1% of the managed forest annually
- Replace softwood plantations with diverse mixes of native species

While the Division's silvicultural practices over the years have produced substantial revenue that currently approaches $1 million annually, revenue production has never been a primary objective of these practices. Within this framework, Division foresters have been able to practice forestry with equal attention to harvesting and to the protection and enhancement of the resources remaining once the harvest is complete. Over decades of applying these forestry practices, the watershed forests have increased in value, both economically and as protection for the drinking water supply, without compromising their broader ecological functions.

The secondary objectives of management are generally compatible with the primary objective of fostering a watershed protection forest. The main focus of improving species-site associations and stand quality will be the conversion of stands dominated by old field white pine to mixtures of hardwood or hardwood and pine. Conversion of conifer cover to hardwoods generally enhances overall water yield. The successful regeneration of poor quality stands will produce a more vigorous and stable, higher quality, and more productive forest. In a general way, wildlife conditions will be improved by increasing species and structural diversity within the forest community. These changes will enhance biological diversity at the landscape level by creating critical areas of early successional growth.

In order to address the goal for structural diversification of the watershed protection forest, the Division will work to systematically regenerate a portion of that forest on an annual basis. 5,250 acres of the managed forest at Ware River will be converted to a new age class over the next 30 years. For this age class to become evenly distributed throughout Division land and evenly spaced through time, 175 acres must be regenerated each year. This overall approach is depicted in Figure 5.

FIGURE 5: CHANGES IN WARE RIVER FOREST AGE STRUCTURE VIA SILVICULTURE, 2003-2063



5.7 Silvicultural Practices to Address Ware River Forest Management Objectives

The application of silvicultural treatments is designed to accomplish some predetermined objective. Formation of a silvicultural prescription is based on ecological principles, but must often be altered to accommodate economic and social realities as well. Nevertheless, this prescription serves as an outline for silvicultural application, and as a means for others to understand and evaluate the silvicultural treatments applied in individual stands. There exist few absolutes in a biological system. The myriad of environmental conditions present within a forested ecosystem requires the constant attention of the forester. The ability to observe and reflect on those observations is one of the forester's most valuable skills as the person responsible for designing and implementing silvicultural prescriptions.

Each silvicultural system has advantages and disadvantages that vary with circumstances and with the objectives of management. The complexity of environmental factors present within a stand requires an individualized solution to its silvicultural needs. Application of silviculture is carried out on the stand level, and so may vary within the range of treatments available for that management area.

The guiding objective for the Division's Ware River silvicultural practices is the creation and maintenance of a watershed protection forest, defined by the Society of American Foresters as "an area, wholly or partly covered with woody growth, managed primarily to regulate stream flow, maintain water quality, minimize erosion, stabilize drifting sand or exert other beneficial forest influences" (SAF, 1983). Silviculture is the tool that provides the means to reach the objectives of management. It is the art and the science of applied forest ecology (Smith, 1993). The Germans view silviculture as a master craft which combines the thought of the scientist with the work of the craftsman (Edner, 1940). Silviculture is forest architecture aimed at the design and creation of stands with outward shape and internal construction that will serve an intended purpose, be in harmony with the environment, and withstand the loads of environmental influences (Smith, 1986). It involves the manipulation of forest vegetation to achieve a desired end, implemented within ecological principles that preserve the integrity of the biological system. To paraphrase Aldo Leopold, it is intelligent tinkering done in a manner that saves all the pieces.

A silvicultural system is defined by Smith (1997) as a planned program of treatments in a stand over the whole rotation or lifespan of the stand. Its purpose is to control the growth and reestablishment of the forest. From an ecological point of view, it is an artificial disturbance that imitates the natural processes and forces that are inherent within the forest. There are two recognized categories of treatments in a silvicultural system: methods of reproduction and intermediate or tending operations. Methods of reproduction remove all or portions of an existing stand and create conditions favorable to the establishment and growth of regeneration. Tending operations are intermediate procedures to improve composition and vigor and to optimize growth of the existing stand.

The name of a silvicultural system is commonly derived from the name of the reproduction method that is used to regenerate the stand. The reproduction methods that will be employed in managing the current Ware River forest include small-group selection cuts ranging from single trees to two acre openings, full overstory removals on up to five acres, and overstory removals with retained structure on up to ten acres. The tendency to pigeonhole a complicated and highly variable process into a pre-defined term can unnecessarily restrict the wide variety of techniques that need to be available to forest managers to address the wide variability in existing stands. "Formulation of a silvicultural system should start with analysis of the natural and socioeconomic factors of the situation. A solution is then devised…When the important act of inventing the solution has preceded far enough the less important step of attaching a name to it can be taken" (Smith 1996).

In general, this silvicultural system for the watershed protection forest at Ware River includes intermediate cuttings, regeneration establishment cuttings, and cuttings to release established regeneration.

5.7.1 Intermediate Cuttings

Intermediate cuttings are performed on stands prior to maturity, preferably when they are in the "pole" size (approximately 5-9" dbh). They are designated as "thinnings" when the objective is to remove trees of low vigor thereby decreasing competition within the stand and increasing the vigor and growth rate of the remaining trees. "Improvement" operations are designed to adjust the species and quality composition of stands. In fact, virtually all intermediate cuttings are a combination of both thinning and improvement. The defining characteristic of all intermediate operations is that there is no specific intention regarding the establishment or encouragement of regeneration; the focus is on enhancing the existing overstory.

In the Ware River forest, intermediate cuttings are rarely performed as the sole objective. Pole-sized stands are uncommon on Division property on the Ware River watershed. Some intermediate operations are performed simultaneously with preparatory and regeneration cuts (described below), including stands that are being treated for the first time without the benefit of prior management.

5.7.2 Establishment of Regeneration

There is no hard and fast rule for determining whether or not an existing level of regeneration is adequate, although Massachusetts Forest Cutting Practices regulations require 1,000 stems per acre of species well suited to the site. The Division considers at least three factors that determine "adequacy": the species composition and its site suitability; the number of seedlings/saplings per given area; and the spatial arrangement of regeneration. A high number of seedlings well distributed but of a species poorly suited to the site is considered inadequate. Conversely, a patchy distribution of a variety of species well suited to the site may be adequate if it occupies enough of the area to warrant release as a new age class.

On sites where the level of regeneration is considered inadequate, establishment or seed cuttings may be prescribed. These are designed to open the canopy sufficiently to increase light and heat levels at the forest floor thereby stimulating seed germination and seedling development. At the same time, the species composition of the overstory, and therefore the makeup of the seed sources, can be adjusted, the leaf litter can be scarified to enhance the seedbed, and competing vegetation can be reduced.

In situations where a desired species is absent from the overstory and therefore a seed source is unavailable, enrichment planting will be considered. The most common examples of this situation are dry site mixed oak stands with no white pine component in the overstory. The only practical method to establish white pine in these stands is through planting.

5.7.3 Release of Regeneration

5.7.3.1 Single Tree and Small Group Selection Cutting

Once adequate regeneration is in place, it will be released systematically to give it light and space to grow. This is accomplished by harvesting a portion of the overstory from designated stands. A relatively wide range in opening size allows for the successful regeneration of a wide diversity of species with varying shade tolerances. In stands where species composition is well-suited to the site, and where there is not a particular concern about impending disturbances, watershed protection objectives will be met with openings ranging from single trees to patches up to two acres in size. This approach to releasing regeneration will also be applied in buffer and filter areas except that Commonwealth regulations restrict release cutting to not more than fifty percent of the basal area, and require that the remaining stand be well-distributed throughout the buffer or filter. Maximum opening size in these filters and buffers will be a quarter acre.

5.7.3.2 *Variations on Shelterwood Regeneration Methods*

The shelterwood method has been used successfully to establish regeneration of a wide variety of species throughout the Division properties on the Ware River watershed. The traditional shelterwood method involves gradual removal of the overstory over two or three cuttings but within the final twenty percent (or less) of the rotation for the stand. Because this method results eventually in the full removal of the overstory, it typically perpetuates an even-aged stand. However, by leaving the residual stand to grow once regeneration has been established and released, the shelterwood method can also create a two-aged stand where that is desirable. Five variations of the shelterwood method have been employed over the years by Division foresters on the Ware River watershed: the traditional shelterwood method, using one, two, or three cuts to remove the residual stand; the extended shelterwood method, in which the final removal cuts are long-delayed; the shelterwood with reserves, which uses the same procedure but retains a portion (at least 20-30 square feet of basal area per acre) of the residual stand; a two-aged approach in which one half of the stand is regenerated at a time; and the group shelterwood method, in which the stand is regenerated by first cutting small groups and then gradually expanding these groups over successive cuttings.

5.7.3.3 *Full Overstory Removals*

Where it is desirable to rapidly convert stands comprised of species poorly suited to the site or unstable stands of damaged or low-vigor trees, full overstory removals of limited size will be conducted. Overstory removals larger than two acres may be the desired option under the following situations:

- ***Plantations.*** A common example in which full overstory removals may be desirable is plantations (most comprised of red or white pine and Norway or white spruce). Some of these plantations were never thinned and consequently the trees are tightly spaced with short, narrow crowns. These stands are poor candidates for small openings or partial overstory removal due to the poor form and inadequate wind-firmness of the residual trees. The most practical method for regenerating these stands is the removal of larger blocks of overstory trees.

- ***Poor quality stands.*** White pine/hardwood stands that originated with the abandonment of agricultural fields and pastures are the most common poor quality stands on the Ware River watershed. White pine that grows in these open conditions frequently suffers multiple injuries to the terminal shoot from the white pine weevil, *Pissodes strobi*, which results in multi-stemmed tops with poor resistance to damage by wind, ice, and snow. Stands which originate from pastures may also be dominated by the few species that were not grazed and by poorly-formed open-grown individuals.

- ***Degraded stands***. Degraded stands on purchased land where previous landowners have high-graded stands (the highest value trees removed, leaving poor quality trees) and/or allowed poor harvesting practices (excessive damage to residual trees, incomplete removal of poorly-formed or diseased trees) are also present on the Ware River watershed. Regardless of the cause, the result is high-risk stands of low quality, low vigor, and often physically damaged trees. An overstory comprised of such trees is not an ideal watershed protection forest. These stands often have diverse advanced regeneration that responds well to being released. Large blocks of overstory trees will be removed in order to rapidly restore these stands to a more desirable condition.

5.8 Non-Harvest Silviculture on Sensitive Sites

There are areas across the watershed where adding new age-classes in order to improve resilience is a high priority but conditions do not allow commercial operations. Examples include steep slopes and areas where soils will not support conventional machinery. On limited areas totaling less than 100 acres during this management period, overstory manipulations may be conducted without removing forest products. The Division will select only those sensitive areas where there is a clear threat of overstory loss and where this event could negatively affect a tributary or shoreline area. Examples include pine plantations with restricted access and high hurricane exposure.

The technique would remove the minimum amount of overstory to allow understory development of either native regeneration or planted trees. Efforts would be made to fell trees across the slope, and to lop the branches to reduce fire danger. This method has the advantage over natural disturbance of methodically selecting both the timing and the placement of openings, which then fill with younger age classes and "anchor" the area in the event of a major overstory disturbance. There will be negligible risks of soil disturbance or erosion in these areas as the trees will not be removed.

5.9 Strategic Approach to Forest Management and Associated Silviculture

The purpose of this plan is to outline an approach for forest resource management on Division lands to meet Division goals at all levels. An integrated approach to planning and managing presents the best strategy to accomplish multi-level objectives. Managing to assure a continuous supply of pure water is generally compatible with other goals of maintaining forest vigor, diverse wildlife habitat, and landscape level biological diversity. Maintaining all ecosystem parts and functions (biological integrity) provides stability, which ultimately provides the best resource protection.

The approach adopted for the management of the forest at the Ware River consists of three separate strategies, which will guide management in different areas. As a group these strategies give Division foresters flexible tools with which to address the primary objective of water quality protection as well as a variety of secondary concerns such as biological diversity and aesthetics. They also match the intensity of the silvicultural practices to the sensitivity of resource areas to these activities. Strategy 1 will eliminate silvicultural operations in portions of the forest. Strategy 2 will employ limited silvicultural treatments in areas where silviculture is limited by regulation, including riparian filters and roadside buffer areas. In Strategy 3, all described types of silviculture will be employed to address a range of management and habitat goals. A more detailed description of the strategies and associated silviculture follows below. Figure 6 maps these strategies across the watershed.

5.9.1 Strategy 1: Restricted Management.

5.9.1.1 Description of Strategy 1 Areas

The purpose of this strategy is to avoid the risk of negatively impacting sensitive resources and to maintain some areas with minimal human impact for aesthetic, research or conservation reasons. In restricted areas no stand-level silvicultural operations will be conducted, although some cutting may be done for public safety or aesthetic reasons. Fire management is also an option in these strategy areas, to suppress wild fires or to maintain fire communities. The criteria used to select areas for this strategy include:

- *Open water*, which also includes shrub swamps and other non-forested wetlands.
- *Permanent forested wetlands* in which harvesting may be permitted but where the potential benefit to watershed protection is not worth the potential risks of harvesting.
- *Remnant "old growth*" stands that are to be retained in an unmanaged condition.
- *Inaccessible areas* that are difficult or impossible to access for management purposes.
- *Aesthetic and high recreation use areas.*

Approximately 5,720 acres that fall into this strategy category have been mapped on the watershed.

5.9.1.2 *Silviculture in Strategy 1 Areas*

The areas associated with this strategy have been removed from active silvicultural management for the variety of reasons described above, all of which prohibit stand-level treatments. Changes in these forest areas will primarily be the result of natural disturbance and mortality patterns. Limited cutting of trees may occur within these restricted areas. For example, if a natural disturbance creates a safety hazard along a road or recreational path, trees may be cut to reduce this hazard.

5.9.2 Strategy 2: Management Limited by Regulation.

5.9.2.1 *Description of Strategy 2 Areas*

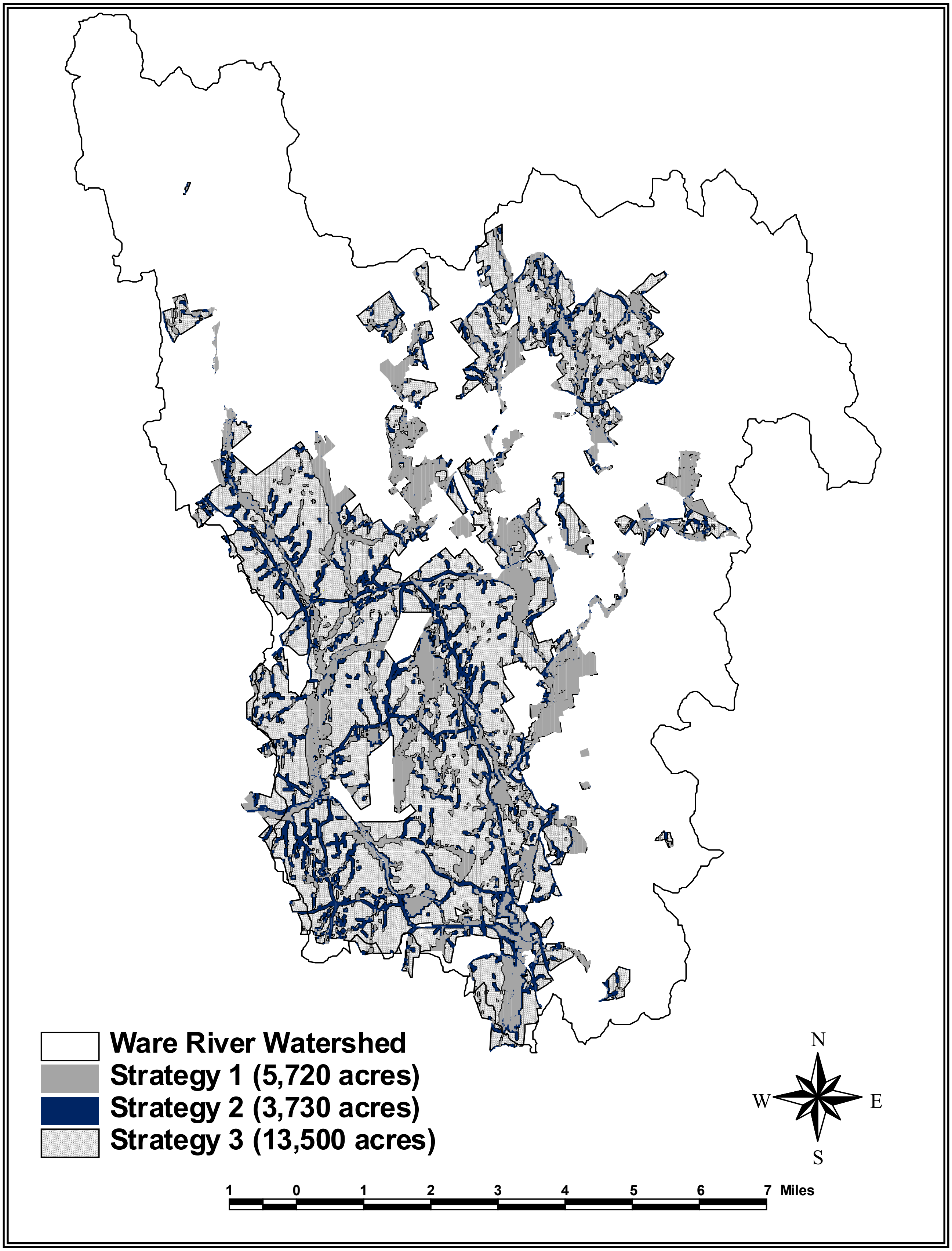
In Strategy 2 areas, existing regulations under Chapter 132, the Massachusetts Forest Cutting Practices Act, limit harvesting. Silvicultural operations will employ the partial cutting techniques allowed by law. The areas treated with this strategy are riparian filter strips and buffer strips along roadways. Commonwealth law restricts cutting to not more than 50% of the basal area in filter and buffer strips, and requires that the residual stand be well-distributed. The purpose of this strategy is to diversify forest structure at the stand level in order to increase forest resistance and resilience, to adhere to statutory regulations, and to minimize visual impacts of silvicultural operations along heavily traveled roadways. The criteria used to select areas for this strategy are:

- *Riparian filter strips* adjacent to tributaries and water bodies, which are legally a minimum of 50 feet (the Division sets this at 100 feet for all vernal pools), varying up to 450 feet depending on the slope and resource significance.

- *Roadside buffer strips* legally 50 feet back from the edge of publicly-maintained roads, 100 feet from scenic roads, with some exceptions for public safety.

Areas mapped for the application of Strategy 2 cover approximately 3,730 acres, including an estimated 500 acres around vernal pools. Note that in mapping these areas, the Division uses a 100 foot filter or buffer as this is typically the width that is maintained, even though the minimum is 50 feet.

FIGURE 6: WARE RIVER SILVICULTURAL STRATEGY AREAS



5.9.2.2 Silviculture in Strategy 2 Areas

The areas that fall into this category include filter and buffer strips near water resources and roadways. The Massachusetts Forest Cutting Practices Act requires that fifty percent of the stand basal area be retained at the time of cutting in filter/buffer zones, and that the residual trees be well-distributed. This limits the silvicultural options available. Single-tree selection or the extended variation of the shelterwood regeneration method will frequently be employed in these areas when the Division seeks to diversify structure or species composition. No more than 50% of the basal area in buffer and filter areas will be removed, and openings will not exceed a quarter acre. The goal in these areas is to regenerate the stands over a long period of time to minimize impacts. Some selected stands will be managed using an extended rotation of up to 200 years to maintain an "old growth" element.

Stream Riparian Area

5.9.2.2.1 Riparian Filters

The most common riparian zone management approach that land managers take is simply to leave these areas alone. In fact, this approach has the force of law in many states, as a component of wetland protection or timber harvesting regulations. MGL ch. 131 (Wetlands Protection Act) and ch. 132 (Forest Cutting Practices Act) both contain language that restricts activities within riparian zones. The assumption behind these regulations is that their critical function in filtration of nutrients and sediments can be impaired if soil compaction and losses of vegetative cover are not carefully controlled. The Division recognizes these zones as the final and therefore most critical opportunity to control potential pollutants released by a variety of natural and human-caused events on the watersheds.

Ch. 132 requires a 50 foot minimum riparian filter for forestry purposes for all water bodies (including certified vernal pools). For Outstanding Resource Waters and their tributaries (which includes the Ware River and its tributaries), this filter strip increases with slope, up to 450 feet for a 100% (45 degree) slope. Machinery is generally not allowed to operate within the filter strip, and cutting is limited to not more than 50% of the basal area. The cutting limitation is applied to a 100 foot buffer zone around all vernal pools, certified or not, on Division watersheds. Note that the Division has mapped these areas as 100 foot filter strips along water bodies, representing the average width that is maintained (a 10% slope requires a 90 foot filter strip). In practice this strip may vary from the 50 foot minimum to the 450 foot maximum required.

The vegetative structure of riparian zones preferred by the Division is an actively growing, diverse, self-perpetuating, and disturbance-resistant forest cover. Maintaining this forest structure throughout the variety of disturbances that impact all New England forests may be best accomplished through carefully planned and implemented human intervention. To some degree, being located within the bottom of stream and river valleys shelters riparian forests from wind damage. However, as these forests mature, and especially where they are in the path of prevailing storms, they become vulnerable to sudden and dramatic damage.

Riparian forests that are simply left alone may establish regeneration as the overstory begins to age and decline in vigor. However, where full crown closure is maintained for long periods of time, understory development will be limited by low understory light and thus there will be delays in recovery following major disturbances. Through carefully implemented manipulations of the overstory and understory, Division foresters intend to systematically "condition" certain vulnerable riparian forests to be better able to fulfill their critical buffering functions throughout significant disturbances, while avoiding soil compaction and carefully controlling the pace of silvicultural changes.

Silvicultural removals will occur within the riparian forest where soils and cutting practices allow. Where appropriate, directional felling of small groups and individual trees, without removal, will be done to bring light to the understory and stimulate regeneration where soils prevent equipment of any size. Trees will be felled perpendicular to prevailing slopes and cut into sections so that the trunk comes in contact with the ground to enhance the sediment trapping capabilities of the riparian zone. Where necessary, seedlings will be planted to enrich the understory.

These practices will be applied in:

- Areas where an important riparian area is involved.
- Areas that are exposed to significant disturbance, such as from future hurricanes.
- Areas where regeneration is sparse or absent.

5.9.2.2.2 Buffer Strips along Roadways

Harvesting practices in buffer strips along highways are regulated by Chapter 132. The objective of these regulations is to maintain a desirable aesthetic appearance along the regulated roadways. The roadways affected are publicly-maintained, except that forest management roads in federal, state, county, or municipal forests, parks, or reservations are excluded, since these are generally interior roads. The 50 foot aesthetic buffer will be maintained where Division-controlled property is adjacent to public roads, except where these roads are designated scenic roads, in which case the buffer will extend 100 feet from the edge of the road. For mapping of Strategy 2, these buffers are set at 100 feet from each side of affected roads, as they are typically maintained at this width. Cutting within these strips is limited to 50% of the basal area.

Occasionally, the Division receives a request from highway maintenance authorities to remove trees along the roadside more completely than required for buffer strip maintenance, for example if a dense conifer plantation is slowing the melting of ice from the highway surface, or a stand is frequently dropping trees in the road during high winds. The Division will accommodate these requests following consultation with the regional DCR Service Forester. This practice may result in full overstory removals within the buffer strips along short stretches of highway.

5.9.3 Strategy 3: Varied Management Options.

5.9.3.1 *Description of Strategy 3 Areas*

This strategy addresses all the land not included in Strategy 1 or 2. The full range of silvicultural options described below will be available to manage stands under this strategy. The objective is to diversify the age structure and species composition of this portion of the forest to increase resistance and resilience of the forest and to address the concerns of other demands on the land including management for biological diversity. The areas where Strategy 3 will be used include the upland sites that are located farthest from water resource areas, and total approximately 13,500 acres.

5.9.3.2 Silviculture in Strategy 3 Areas

The areas in this category are all of the forest that fall outside of the Strategy 1 and 2 areas. Silviculture will be applied according to the needs of the stand. The full range of silvicultural tools identified in this plan, from single tree selection to five-acre full overstory removal will be available, as well as limited numbers of larger openings (up to ten acres in size) with retained structure. The objectives in these areas are to protect the water supply by creating an all-aged forest, to maintain a portion of the Strategy 3 areas in early successional habitats, and to provide a range of habitats for native biota.

In addition to single-tree and small group selection cutting with openings up to 2 acres in size, this strategy area will use variations of the shelterwood regeneration method. The traditional shelterwood method, which employs two cuts to remove the residual stand; the shelterwood with reserves which uses the same procedure, but retains an element of the residual stand indefinitely; and a two-aged approach in which one half of the stand is regenerated at a time will all be employed in the treatment of stands. Full overstory removals up to five acres in size will be used in some softwood plantations to rapidly convert these areas to mixtures of native species and to create viable, though temporary early successional habitat. Shelterwood cuttings that remove all but 20-30 square feet of basal area within an area of up to 10 acres will also be employed, for instance to more rapidly convert old field white pine to mixtures of pine and hardwoods.

5.10 Predicted Results of the Three-Strategy Approach

This management approach combines several strategies to meet both water quality and diverse secondary goals. It directs management away from the most sensitive water resource areas and many of the heavy use areas. It also provides aesthetic zones along the major thoroughfares and waterways that bisect the forest unit. In addition, this management approach provides a means of tracking forest development over time to ensure that goals are being met at the forest level as well as the stand level. It also provides critical elements of biodiversity that are lacking at the landscape level, including blocks of old forests and early successional forest habitats.

Watershed Protection: This three-strategy forest management approach has been designed to provide a forested watershed that will provide excellent watershed protection. When fully implemented, about 85-90% of the forest will have a diversified age structure and species composition. The majority of the forest should be resistant to, and resilient after, disturbance. About 15-20% of the forested area at any given time will be composed of young forest that is not easily damaged by major wind disturbances. Partially cut areas and intermediate thinnings will develop an understory of advance regeneration that can replace the overstory in the event of a catastrophic disturbance event, and should produce robust, well-tapered individuals that are more resistant to wind, snow, or ice damage.

This forest management approach directs harvesting operations away from tributaries and major wetland and water resource areas. The three strategy areas will be managed with a carefully controlled silvicultural approach. Some of the Strategy 2 stands will be managed with long rotations to maintain aesthetic values. Over time, the number of active skid trails and the number of stream crossings will be held to a minimum. All proposed operations will be done with equipment on which size and season limits will be imposed to regulate its impact on the broad forest resource.

Wild Character: The wild character of these forested, undeveloped watershed properties will be perpetuated by this plan, although they will receive periodic silvicultural treatment. Approximately 25% of the forest will be removed from active management and an additional 50% will receive partial cuttings, with some managed under long rotations. Many Strategy 1 and Strategy 2 stands are contiguous and will therefore form large areas with limited management activity.

Wildlife Habitat: The integration of different strategies in this management approach addresses the broad spectrum of environmental needs for native fauna and flora, from old unmanaged stands to young recently harvested areas, and from large blocks of uninterrupted canopy to smaller mixtures of trees of all sizes.

Forest Vigor: This management approach provides high species, structural, and spatial diversity. Diversity in a general way leads to a stable, vigorous forest condition able to respond to the variety of stresses and disturbances that will occur within an ecosystem. This diverse forest condition is accomplished by applying all the management tools available to create and maintain the wide range of conditions that suit forest growth and development. Having the ability to apply the appropriate tool to the conditions that are specific to a particular stand is critical to the success of a silvicultural prescription. The success of the prescription will determine in many cases the diversity of the stand composition and the appropriateness of its species-site association. These in turn will have an impact of the vigor of individuals in the stand, and ultimately on the vigor of the forest as a whole.

5.11 Implementation of the Three-Strategy Management Approach

Stands to be treated by Strategy 1 and 2 have been identified and mapped, and all remaining areas will be treated with Strategy 3 (Fig. 6). There are approximately 5,720 acres mapped to be treated by Strategy 1 and 3,730 acres by Strategy 2, leaving approximately 13,500 Strategy 3 acres on which the range of silviculture described in this plan will be applied (Fig. 7). The boundaries between strategy areas were chosen to be easily identifiable to ensure their integrity. For administrative purposes, Division holdings on the Ware River watershed have been divided into 50 units or compartments averaging slightly less than 500 acres in size. Compartments have been numbered 1 through 50 from southwest to northeast. Each compartment and all stands within those compartments will be visited on ten-year intervals (five compartments per year, 2,500+/- acres). Stand examinations will be conducted on these visits and the data collected will be used to prioritize stands needing silvicultural treatments. These data will be entered into a database to create long term profiles of stand and forest level change to augment the CFI system. Data collected for each stand will include:

- Stand density (basal area)
- Stand height
- Forest type
- Stand age
- Regeneration type and adequacy
- Stand condition (vigor/ quality)
- Special features (unique habitats, vernal pools, significant forest and wildlife features).

Silvicultural activities will be dispersed across the watershed to enhance diversity and aesthetic amenities by following a sequential pattern. The first year compartments 1,11,21,31,41 will be examined, with 2,12,22,32,42 examined the second year, and so on until the entire forest has been covered. This planned pattern may be disrupted by the need to address pest or weather disturbances, but will generally dictate the areas to be treated.

Priorities for treatment will be set using stand examinations in each of the five compartments. To achieve a diverse age structure, about 1% of the acreage in Strategy 2 and 3 areas will be regenerated annually. In the areas limited to small group selection cutting, this will require treating about 2% of the area annually, because 50% of the residual stand will remain. When fully implemented, the cutting regime will balance the age structure of the forest in these areas.

Stands within Strategy 2 or 3 will be prioritized for silvicultural work as follows:

- Low quality softwood stands with high susceptibility to disturbance.
- Softwood plantations of non-native species or with high susceptibility to disturbance.
- Softwood stands with advance regeneration in place.
- Hardwood stands with advance regeneration in place.

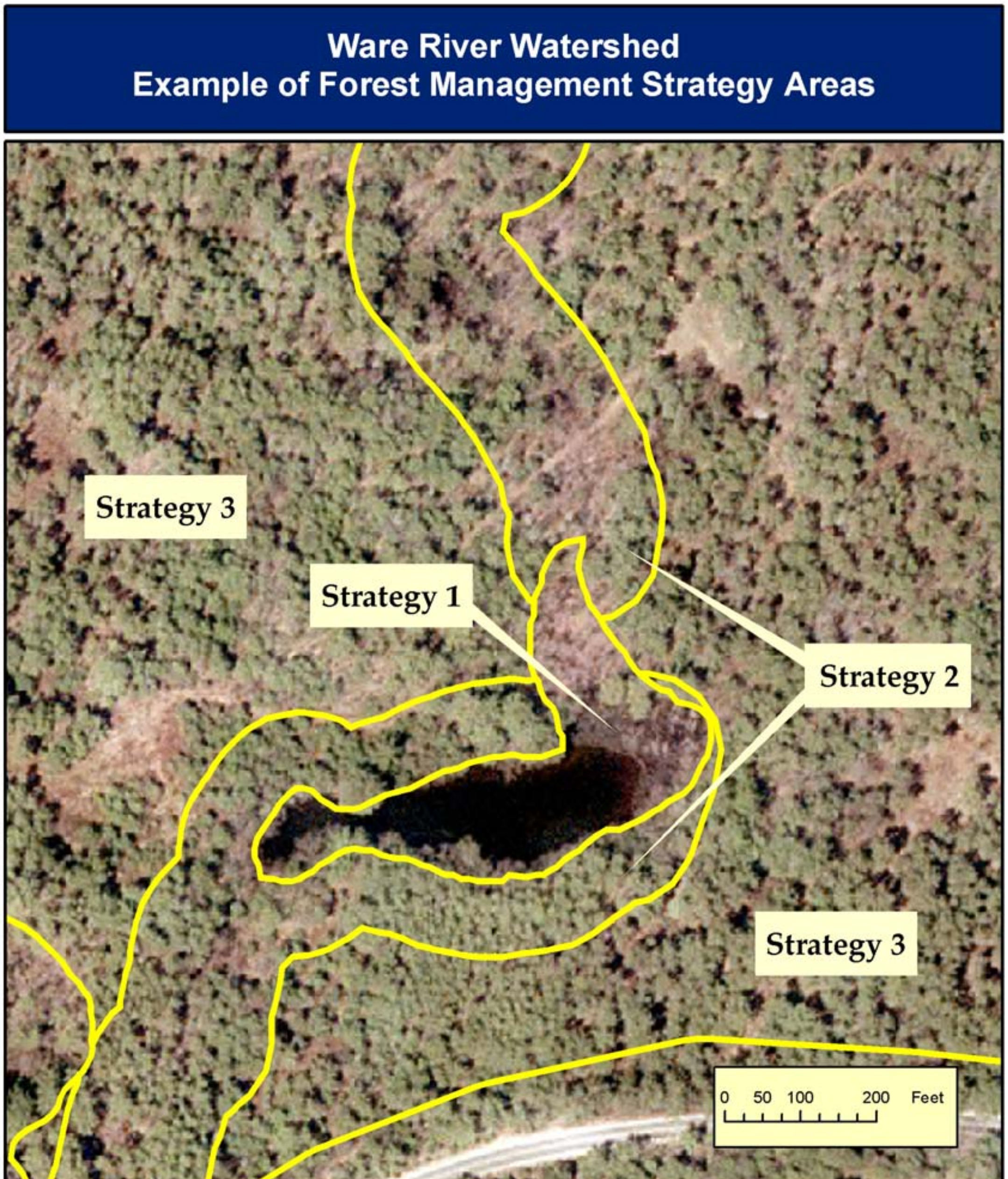
Table 6 below outlines the range of silviculture within each management Strategy, and the target objective for number of acres within each Strategy to be regenerated to create or release new age classes within the 10 year management period covered by this plan. Stand conditions at the time of inspection will determine, especially within Strategy 3 areas, the silviculture that will be applied from within the choices for that strategy. Stand conditions that will influence this decision on the ground include:

- Presence or absence of stand-wide health concerns (e.g.,a widespread presence of root-rot fungi or damage by defoliating insects).
- The silvicultural history of the stand, including recent harvesting.
- Presence or absence of advance regeneration.
- Seed source for regeneration; timing of seed production by overstory dominants.

TABLE 6: STRATEGIES, SILVICULTURAL OPTIONS, AND ANNUAL REGENERATION OBJECTIVES

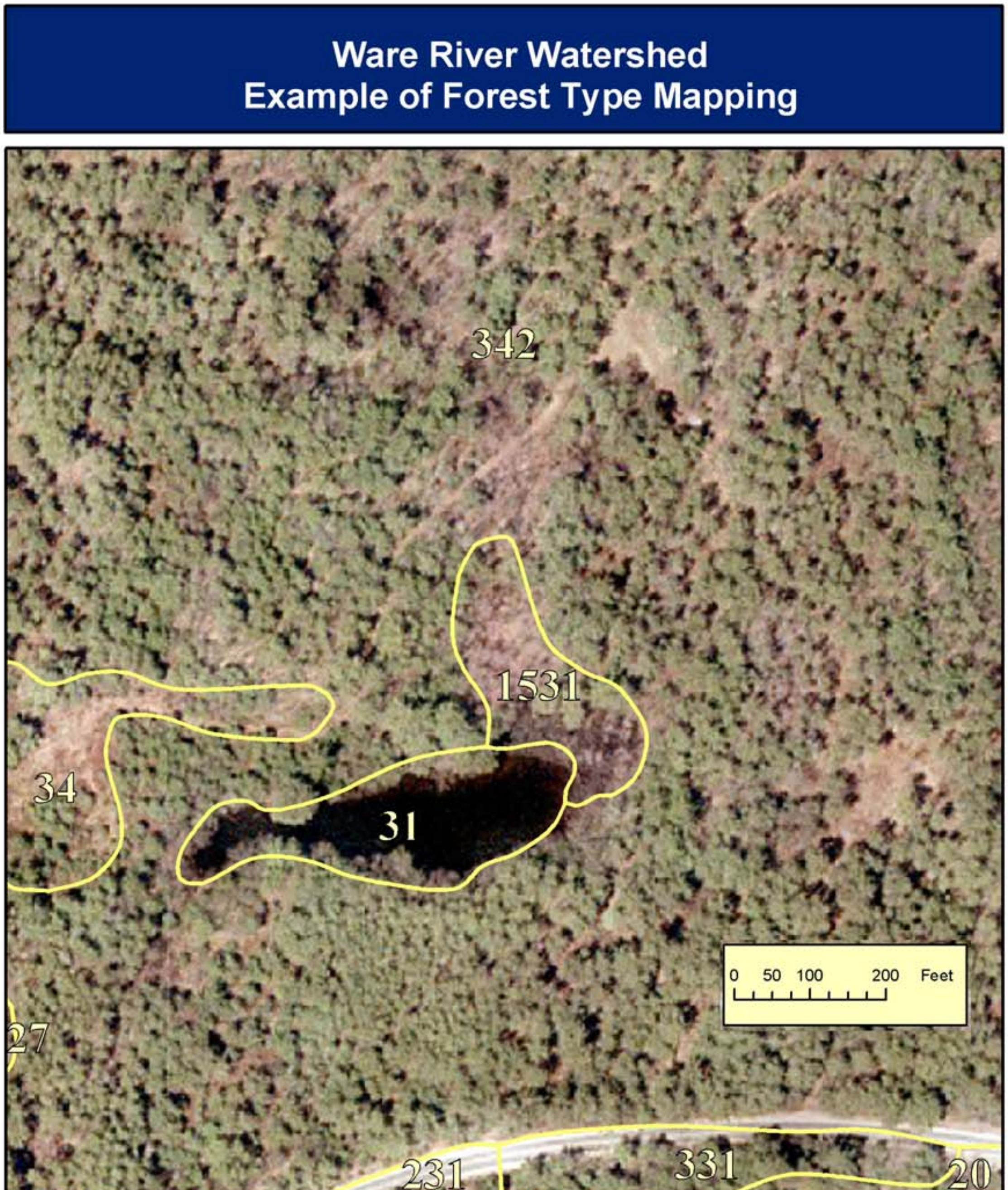
Strategy	Approximate Acreage	Silvicultural Options	Annual Regeneration Objectives
Strategy 1: Restricted management	5,720	Non-commercial cutting, non-harvest removals	Unspecified; mostly whatever nature provides
Strategy 2: Management limited by regulation (riparian filters, road buffers)	3,730	Single tree and small group selection up to 0.25 (one quarter) acre	Regenerate 40 acres/yr
Strategy 3: Varied management options	13,500	Single tree and small group selection up to 2 acres; full overstory removals up to 5 acres; overstory removals of up to 10 acres when 20-30 sq ft basal area is retained within the removal area	Regenerate 40 acres/yr using single tree to small group selection up to two acres, averaging one acre; 65 acres/yr using selection and full overstory removals up to 5 acres; 30 acres/yr using overstory removals up to 10 acres with 20-30 sq ft of retained basal area. Total 135 ac/yr
TOTAL	22,950 acres	Single tree to 5 acre full overstory removal, plus overstory removals up to 10 acres with residual structure.	Regenerate 175 acres/year, or 1,750 acres during 10-year management period

FIGURE 7: EXAMPLE OF FOREST MANAGEMENT STRATEGY AREAS



In this example, the Strategy 1 area is comprised of open water and an adjoining deciduous wooded wetland; no commercial harvesting will be planned for Strategy 1 areas. Strategy 2 areas here include a riparian filter strip of 100' along both sides of streams and surrounding the open water, as well as a 100' roadside buffer. A maximum of 50% basal area may be harvested in these areas, leaving residual trees well-distributed. Strategy 3 areas in this example include white pine/hemlock and white pine/hardwood stands of various age classes and stocking levels, as well as a gravel pit. A range of silvicultural practices will be considered for all Strategy 3 areas; stand conditions and management objectives will guide silvicultural prescriptions.

FIGURE 8: EXAMPLE OF FOREST TYPE MAPPING



20 ....Upland Brush
27 ....Beaver Meadow
31 ....Open Water
34 ....Gravel Pit
231.....................White Pine / Hemlock, 40 - 60 feet, high stocking
331 ....White Pine / Hardwood, 40 - 60 feet, high stocking
342 ....White Pine / Hardwood, 60 - 80 feet, medium stocking
1531 ....Wooded Wetland -Deciduous, 40 - 60 feet, high stocking

5.12 Ware River Forest Types and Silvicultural Needs

The Ware River forest is a conglomerate of forest types, determined by overstory species composition, which are in turn the result of site conditions, past land use practices, and natural disturbances (Fig. 8). The major types occurring on the Division properties on the watershed are described below, as well as the silvicultural needs of these types, which will be adjusted according to the overlap between forest type and management strategy for any given stand. Where these types fall within Strategy 1, silviculture will not occur, although there may be very limited cutting for protection or aesthetic purposes. Where types overlap with Strategy 2, regeneration silviculture is limited to openings of not more than 0.25 acres in size. In Strategy Three areas, the full range of silvicultural options described above will be used to address the silvicultural needs in each of the types described below.

TABLE 7: SUMMARY OF FOREST TYPES AND ACREAGES

Forest Type	Acres
Dry site oak	737
Mesic site oak	221
White pine plantations	200
Natural white pine	1,328
Red pine type	171
Mixed hardwoods	4,023
Red maple	789
White pine-oak	1,428
White pine-hardwood	6,728
White pine-hemlock	4,325
All other types	3,000

5.12.1 Oak Type

The oak type is best divided into two sub-types based on site characteristics, dry site and mesic site oak.

5.12.1.1 Dry Site Oak Type

Scarlet, black, and white oak are the primary species along with red and chestnut oak, white pine and red maple. This type occupies approximately 737 acres, typically on excessively drained outwash soils and thin-to-bedrock till soils. Most of these forests owe their composition to a combination of past heavy cutting practices, fire history and the loss of American chestnut. These stands are typically of low vigor with slow growth rates, lacking in adequate regeneration and are the stereotypical “hotspot” where gypsy moth infestations arise.

The primary goal of management in these stands is the introduction of white pine as a component. White pine is far better suited to these sites. It is capable of superior growth than the oaks and regenerates well. There are stands where white pine exists as a scattered co-dominant, and sometimes dominant member of the overstory. These trees are highly valued as a seed source for future pine regeneration and their ability to function in this role is enhanced by removing competing trees from around them while creating a desirable seed bed throughout the stand by partial overstory removal. Planting is a commonly used option where white pine does not exist as a seed source, and has shown good results. Pitch pine will be considered for introduction (it presently exists but sporadically and in very low numbers) into the very driest sites, where it is especially well-adapted.

5.12.1.2 Mesic Site Oak Type

These stands, which occupy approximately 221acres, are comprised of red, black and white oak with the hickories, red maple, black birch, and white pine as the most common secondary components. They are similar in origin to the dry site oak type but differ due to their occurrence on more mesic, moderately-drained sites. These stands will be converted to a greater diversity of species especially white pine and the longer-lived hardwoods such as hickory. The oaks, which are prime examples of the long-lived, low maintenance species that are sought for the watershed forest, will be maintained as a significant component.

5.12.2 White Pine Type

This type is broken into sub-types based on stand origins. Only stands that are still predominantly composed of pine will be considered plantations. Many stands that originated as pine plantations have regenerated to a mix of natural pine and a significant component of hardwoods and will be included in the discussion of natural white pine stands.

5.12.2.1 Plantations

The only definitive character of the sites occupied by white pine plantations is that there is no pattern. Plantations were established on 200 acres on virtually every soil type from xeric outwash soils to poorly drained tills. Unfortunately, the one common factor is that until the 1980s, these stands did not receive the thinning operations that planting at a six by six foot spacing necessitates.

The goal of management for all of the plantations regardless of soil type is the conversion to an appropriate, site-suited diversity of species. On the more moist sites, white pine will become a minor component in a hardwood mix. On the drier sites, white pine will persist as a significant component.

5.12.2.2 Natural White Pine Type

Natural stands that are composed primarily of white pine most commonly originate in abandoned fields and pastures. There are currently 1,328 acres of this type. The pine's relatively heavy seed, unlike the lighter-seeded hardwoods, is capable of falling through the thick grass in fields. The result is stands of nearly pure white pine in old fields, typically surrounded by stonewall. Pine that develops under these conditions is commonly attacked by the white pine weevil resulting in crooked, multiple leader stems. Such trees are more susceptible to wind and snow damage. Where these stands are heavily stocked with very limited understory development, the goal of management is to diversify the species composition, introduce new age classes and remove the individuals of poorest growth form.

5.12.3 Red Pine Type

All of the red pine in the Ware River forest was established by planting during the last century. Today, approximately 171 acres of red pine plantation remain. As was the case with white pine plantation, red pine was planted on a wide variety of soil types, many that are not well suited to the long-term development and regeneration of red pine. Red pine will grow very well on moister, more fertile sites. It is also, however, highly prone to root damage and subsequent disease problems and windthrow on these sites. Red pine is well suited to growth and development on drier soils and it is on these sites that a component of red pine will be maintained while encouraging an increased diversity of appropriate species. On the more mesic sites, red pine will gradually be eliminated as a component of the stands.

5.12.4 Mixed Hardwoods

There are approximately 4,023 acres of forest comprised of a variety of hardwood species. Red maple, white ash, hickory and red oak are the dominant species along with a component of white pine. This type is most common on mesic soils in mid- to low-slope situations and tends to grade into the red maple type as soil moisture increases. These sites are ideally suited to the growth of highly diverse stands. The focus of management will be the maintenance of this diversity, along with the establishment of new age classes.

5.12.5 Red Maple

Stands dominated by red maple occupy approximately 789 acres. Common secondary species include white pine, white ash, hemlock, red oak and black cherry. Red maple stands occupy poorly drained, wetland sites, as well as non-wetland soils on low-slope sites that support logging equipment with the use of adequate CMPs. Many of these stands are similar to mixed-hardwood stands except for the predominance of red maple, which often tends to be of poor form and vigor. Therefore, the goal of management will be the diversification of these stands at both the species and age class level. A greater component of species such as red oak, white ash, black cherry, yellow birch and hickory will be sought.

5.12.6 White Pine – Oak Type

This type is comprised of predominately white pine and red oak, white oak, scarlet oak and black oak. Many other hardwoods are associated with this type. Approximately 1,428 acres are occupied by this type on the Ware River watershed. It occurs mostly on drier washed till and outwash soils and will be maintained on these sites. The white pine component may be increased on the driest sites.

5.12.7 White Pine – Hardwood Type

White pine, red oak, and other hardwoods predominate in this type. Red maple is the chief associate. This type occupies approximately 6,728 acres on the Ware River forest. Often found on soils that are more mesic than the white pine oak type, many of the stands in this type also originated from abandoned pastures. The red oak component will be increased on the better sites through silvicultural treatments. The quality of the white pine component should increase on all sites because the stands will originate from silvicultural treatments and not abandoned pasture.

5.12.8 White Pine – Hemlock Type

White pine usually dominates this type with hemlocks in the co-dominant or intermediate crown positions. There are many associated hardwoods. Mature stands in this type often have very little understory due to the dense shade of the overstory. This type occupies approximately 4,325 acres at the Ware River. Many of these stands are in the valleys along streams and rivers. The white pine in these stands is usually of high quality due to natural pruning of lower branches by the shade of adjacent hemlocks. These stands will be opened up to develop an understory. The hemlock component will be reduced either directly by hemlock woolly adelgid mortality, or through salvage of infected trees.

5.13 The Role of Natural Disturbances on the Ware River Watershed

Natural disturbances in a forest occur at virtually all scales of time and area. The infestation of a single tree by carpenter ants, the perpetual browsing of deer, and a forest fire are all examples of natural disturbances. These disturbances, though “natural,” can compromise forest structure and vigor and therefore the ability of the forest to protect water quality. It is a principal goal of the Division to insure the supply of high quality drinking water for both the short and long term. The management of the Ware River forest must be planned to mitigate negative impacts resulting from natural disturbances, both large and small scale. The most significant, sometimes catastrophic disturbance that affects the forests of Massachusetts is hurricanes. From meteorological records and forest reconstruction it has been estimated that hurricanes strike southern and central New England every 20-40 years, while catastrophic storms like those of 1635, 1788, 1815 and 1938 occur approximately every 100-150 years. (Foster 1988).

Catastrophic hurricanes have the ability to disturb a significant portion of the forest, suddenly changing species composition and age distributions. There are, however, variables that affect the extent to which a forest is impacted by various windstorms, and some of these can be controlled by foresters. A study of the Hurricane of 1938 at Harvard Forest in Petersham, MA (Foster and Boose, 1992) showed that conifers are more susceptible to windthrow than hardwoods, and tall trees are more susceptible than short trees. These two factors, in combination with the slope and aspect of any given site, are significant determinants of wind damage. In the Harvard study, conifers greater than 34 feet tall and hardwoods greater than 74 feet tall on nearly level sites (<5 degrees) or windward oriented slopes (S,SE,E) were severely damaged (>75% of all trees were damaged); there was intermediate damage (50-75% of all trees were damaged) on mild leeward slopes (5-10 degrees, N,NW,W) or intermediate orientation (NE,SW, >5 degrees). Hardwoods greater than 64 feet tall on these same exposures were damaged 51-75% and 25-50% respectively.

The structure of an uneven-aged forest, with three or more age classes well-distributed across the landscape, is designed to both resist and recover from the impacts of windstorms. Resistance is improved when much of the forest is shorter than the critical height categories according to the Harvard model. Resilience is improved when regeneration is in place and not heavily browsed in the event that the overstory is destroyed. This structure should translate to less risk to water quality in the event of a major windstorm. Fewer trees blown over means fewer trees needing to be salvaged and reduced fire hazard, and therefore a lower risk of subsequent nutrient losses to tributaries and the reservoir.

5.14 Forest Insects and Diseases

Insects and disease-causing organisms are natural components of the forest ecosystem that under ordinary circumstances play a vital role in general biodiversity, decomposition and nutrient cycling, and predator-prey relationships. On the other hand, these organisms are occasionally capable of large-scale infestation and damage, in particular when the specific organism is imported from outside the area and therefore not subject to its normal suite of population-controlling predators. Insects and diseases are a major problem in the Ware River forest only when their impacts conflict with the Division's objective of creating and maintaining a watershed protection forest. For the most part, this includes only large-scale outbreaks that threaten to alter tree species diversity or forest structure. Chestnut blight, which appeared in central Massachusetts in the first decade of the twentieth century, is an example of such a disease. Before the blight, chestnut was one of the dominant trees in the forest; today, it is essentially a minor shrub. Occasionally, an individual may grow to the status of a small tree before again being infected, dying back to the ground and perhaps putting out new sprouts.

Both the fungus that causes chestnut blight (*Cryphonectria parasitica*) and the gypsy moth (*Lymantria dispar*) are introduced organisms that came to the Ware River forest without their co-evolved complement of predators and parasites; a recipe for the development of an outbreak capable of serious disturbance of the forest's function. Other examples that have in the past affected the Ware River forest include Dutch elm disease, beech bark disease, and white pine blister rust. Native insects and diseases are generally kept in check by their predators except when cultural effects create unusual conditions. Examples include establishing species that are unsuited to the site, deliberately creating single species stands (plantations), and growing forests on soils that are nutrient depleted from a long history of farming practices.

Another significant insect threat to the Ware River forest is the hemlock woolly adelgid (*Adelges tsugae*), a small aphid-like insect native to Asia, first seen in the eastern U.S. in Virginia in 1955. Since then it has been moving up the East Coast and is presently in most towns in central Massachusetts. It feeds on hemlock at the base of the needles, removing nutrients and secreting a toxic substance in its saliva. The most recent research and observations indicate that the amount of hemlock in the forests of Massachusetts may be significantly reduced over the next decade or more. While hemlock currently comprises just 6% of the stocking of the Ware River forest, a significant proportion of it occurs in riparian zones and on steep slopes above riparian areas. This makes the loss of these hemlocks potentially more critical from a water quality point of view and also makes the commercial salvage of these areas more problematic. No extraordinary measures will be taken to salvage infested hemlock on upland sites. However, sites deemed more critical to water quality will be considered for salvage operations either through commercial or non-harvest means.

5.15 Salvage Policy

The advancing average age of the Ware River watershed forest and the steady arrival of new insect pests have lead to an increase in salvage cuttings in recent decades. In addition to insect and disease damage, disturbances include windthrow, especially of trees with weakened root structures, and ice and snow damage. Salvage activities are important components of watershed maintenance when the disturbance damages large areas of forest, or greatly increases the threat of additional damage. It is important to note that the Division does not intend to salvage following every disturbance. Many disturbances are small in scope and some are difficult to access or sufficiently remote from water resources or public use areas that they do not present significant hazards or aesthetic concerns. These areas may be left to regenerate on their own without silvicultural intervention although in some situations they may be planted with a mix of tree species to enhance their recovery.

Removals of dead or dying trees from damaged forests can lower fire hazard (e.g., in hemlock defoliated by the hemlock woolly adelgid), allow the salvaging of timber value, and strengthen the resistance of surviving trees (e.g., by removing trees weakened by gypsy moth to improve survival of adjacent trees). The Division is aware of the importance of the steady addition of large woody debris to the forest ecosystem. However, the volume of dead and dying wood that is eventually salvaged is a small fraction of the total mortality in any given period of time. Therefore, ecosystem functions will continue to be met even while other short-term concerns are addressed through salvage efforts.

Where large areas are involved, salvage activities may preempt planned activities described in this plan. Where these watershed forests sit close to residential developments, the priority for salvage following disturbances may increase in order to improve aesthetics and reduce both perceived and actual fire danger. In addition to public pressure for a rapid response, there are often other time pressures driving salvage operations. For example, when white pine is damaged during the warm months of the year, its wood loses value rapidly due to fungal invasions that cause discoloration ("blue-stain"). Wood-boring insects also invade damaged timber rapidly during warmer months and can greatly reduce value. Where roads are blocked by disturbances in adjacent forests, there is also an obvious need to conduct salvage rapidly in order to restore access, which is critical for fire control and emergency response. In situations that involve these time pressures, review and timber harvest permit procedures may be streamlined when an operation is deemed to be salvage and conditions warrant rapid action.

5.16 Conservation Management Practices for Water Supply Forestry

Forest management at Ware River is conducted to improve the protection of the drinking water supply. Short-term impacts from forest management practices must be exceeded by the long-term benefits to water quality protection. Accomplishing this objective requires strict compliance with management practices designed to protect against losses of sediments and nutrients to adjacent water resources. Described below are specific Conservation Management Practices designed to protect water supplies, which is the standard for the Division's forest management. It should be noted that the Division meets or exceeds the requirements of both the Forest Cutting Practices Act and the Wetlands Protection Act (MGL Ch. 132 and 131). Whenever these regulations are revised, Divisions management practices will meet or exceed the revised standards.

Strict adherence to Division Conservation Management Practices (CMPs) ensures that forest management is conducted in a manner that does not impair water resources or other natural/cultural resources on the watersheds. Silvicultural practices, as described in the management plan, are employed to bring about specific forest conditions that protect the water supply. These practices require the cutting and removal of overstory trees to diversify structural and species compositions and to maintain the vigor of the residual overstory. A given forest stand is treated, on an average, every 25-30 years and at that time, 1/3 or more of the overstory may be removed to establish and release forest regeneration. The process of removing trees can impact the forest and soils essential to water quality if not carefully designed, implemented, and monitored.

Among the areas of greatest concern is the placement of forwarder and skid roads and log landings, where logging work is concentrated. Proper location of these in relation to streams, rivers, reservoirs, ponds, vernal pools, and bordering vegetated wetlands is important so that soils do not move from these areas into water or wetland resources. Beyond this principal concern, Conservation

Management Practices are designed to diminish the negative impact of silvicultural operations on the residual vegetation, to minimize soil compaction during these operations, and to keep potential pollutants out of the water resource.

5.16.1 Planning Variables

There are many variables to consider when planning and conducting a logging operation, including equipment limitations, weather, soil depth, soil moisture, topography, silvicultural practices, vegetation, and operator workmanship. Variables such as weather, soil moisture, soil depth, topography, and existing vegetation are constraints placed on logging that must be factored into planning and logging schedules. Variables such as equipment, silvicultural planning, and operator workmanship can be modified, for instance by matching allowable logging equipment with the constraints of a given site.

5.16.1.1 Logging Equipment

Logging equipment has changed dramatically in the 30-40 years that forest management has been active on Division watersheds. The primary logging machine was once the 50-70 horsepower (hp) crawler tractor-sled combination. These tracked machines were 5-6' wide and weighed 5-7 tons. Today, most logging is done with 4-wheel drive articulated skidders or forwarders with 70-100 hp, widths of 7-8 feet, and weights of 6-8 tons. Skidders drag logs attached to a rear-mounted cable and winch, while forwarders carry logs on an integrated trailer.

Other types of logging equipment include grapple skidders, wheeled and tracked feller-bunchers, and feller-processors. A grapple is an add-on feature that replaces the winch and cable with hydraulically operated grapple arms. Feller-bunchers cut trees and put them in piles, usually for removal by a grapple skidder. There are 3 or 4 wheel feller-bunchers that must drive up to each tree for felling, whereas tracked models can fell a tree 10-20 feet from the machine. A feller-processor (usually on tracks) fells, de-limbs, and cuts trees, leaving piles of logs or cordwood, which are retrieved by forwarders.

Small skidders are useful for logging on Division watersheds whereas larger 100-130 hp models, that weigh between 8-11 tons and are 8-9 feet wide, are usually too large and heavy for stand and soil conditions. Combinations of small, maneuverable feller-bunchers and forwarders, small skidders and forwarders, and small tracked feller-processors and forwarders have all worked successfully on Division watersheds. Table 8 shows typical combinations of equipment that work on various types of harvesting operations on Division properties.

TABLE 8: HARVESTING METHODS/EQUIPMENT USED ON DWSP WATERSHED LANDS

Method/Equipment	4-8' Cordwood or pulpwood	8-20' Sawlogs, fuelwood, pulpwood	Whole-tree
1. Chainsaw felling with 4WD pickup truck	√		
2. Chainsaw felling with cable skidding	√	√	
3. Chainsaw felling with forwarding	√	√	
4. Rubber-tired, four-wheeled feller/buncher with grapple skidding		√	√
5. Rubber-tired, four-wheeled feller/buncher with chainsaw limbing and forwarding		√	√
6. Rubber-tired, three-wheeled feller/buncher with grapple skidding			√
7. Tracked feller/buncher with grapple skidding		√	√
8. Tracked feller/processor with forwarding	√	√	

In an effort to specify equipment that is appropriate on specific soils and within specific forest types, the Division has determined ground pressure and width measurements for most of the equipment common to the area, and specifies restrictions, where needed, in timber harvesting permits. Widths are either from direct measurement or from manufacturer's specifications; ground pressures are based upon a formula that combines machine weight and weight of an average load of logs with an estimated footprint for the tire size specified, at an average tire inflation pressure. Examples from this rating system are listed in Table 9.

Forwarder with tracks

Rubber-tired skidder

TABLE 9: SAMPLE EQUIPMENT SIZE/GROUND PRESSURE RATINGS

Machine Model	Tires	Width	Ground Pressure
TimberJack 208	23.1 x 26	102"	4.9 lbs/sq in
JohnDeere 440C	23.1 x 26	102"	5.0 lbs/sq in
Franklin 105XL	23.1 x 26	110"	5.3 lbs/sq in
TreeFarmer C4	18.4 x 26	93"	6.5 lbs/sq in
JohnDeere 540	23.1 x 26	105"	6.6 lbs/sq in
CAT 508GR	23.1 x 26	106"	7.1 lbs/sq in
Clark 665	23.1 x 26	114"	7.9 lbs/sq in
Clark 665	18.4 x 24	104"	9.5 lbs/sq in
TreeFarmer C6	18.4 x 34	97"	10.1 lbs/sq in
CAT 518	18.4 x 34	99"	11.2 lbs/sq in

Mechanil feller

Some of the logging equipment available is too large or heavy to meet Division requirements in certain vegetation or soil conditions, and some is limited by terrain. Matching the equipment with the site conditions so that minimal damage occurs is critical to the success of watershed silvicultural activities. DWSP specifies equipment requirements for each site in its timber harvest permits. This includes machine width and ground pressure limits, as well as specific equipment requirements (e.g., forwarders). While each site has unique conditions that require the experienced judgment of the forester to predict impacts, ground pressures are generally limited to 8 pounds per square inch or less on soils that are less well-drained. Machine widths are limited in intermediate cuttings of dense, unthinned stands with moderate topography, most typically to around 8.5 feet (102").

An example of a "preferred logging system," that accomplishes Division goals under difficult conditions is a small feller-processor and forwarder combination, used for thinning dense pine plantations on a variety of soil conditions. Both machines are able to work in these conditions with minimal damage to roots, stems, crowns, or soils. In addition, these machines can successfully work around walls and foundations and do not require a landing, as logs are stacked on the roadside. This combination can also work in previously thinned stands that have an understory of young pines, with minimal damage to the young growth.

Most feller-processors are limited to stable ground conditions (few rocks and gentle slopes) and trees less than 16" DBH. In older multi-aged stands where the trees are much larger, hand felling is necessary. Multi-aged stands will always have many more stems/acre than the present even-aged stands and consequently are more difficult to work in without damaging residual trees. A combination of a winching machine and forwarder works well in multi-aged stands. This logging system addresses the problem of damage to the residual trees associated with long skid roads.

Table 10 summarizes some of the Division's effort to match equipment and logging systems with site conditions. The methods listed in Table 10 are taken from Table 8.

TABLE 10: HARVESTING METHODS/EQUIPMENT USED IN VARIOUS SOIL/TERRAIN COMBINATIONS

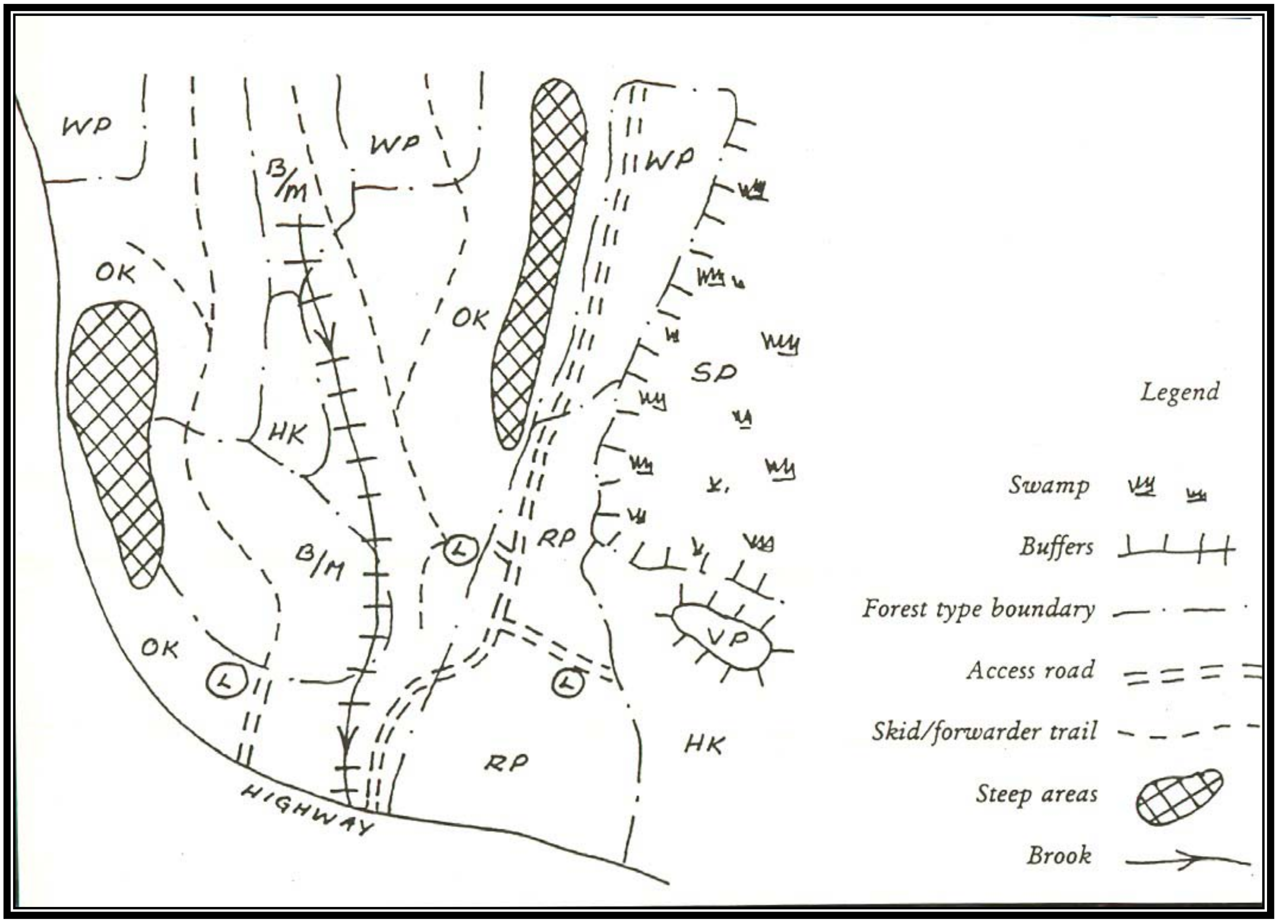
	Excessively Drained Soils	Well-Drained Thin Soils	Well-Drained Thick Soils	Moderately Well-Drained Soils	Poorly to Very Poorly Drained Soils
Level to 10% Grade	Harvesting Methods 1-8	Harvesting Methods 1-8	Harvesting Methods 1-8	Methods 1-8 with frozen or dry soils only; ground pressure < 8 lbs/sq. in	Generally not worked with machines
11-20% Grades	Harvesting Methods 2-6	Harvesting Methods 2-6	Harvesting Methods 2-6	Methods 2-6 with frozen or dry soils only; ground pressure < 8 lbs/sq. in	NA
Slopes Greater than 20%	Harvesting Method 2	Harvesting Method 2	Harvesting Method 2	NA	NA

5.16.1.2 *Silvicultural Planning*

Division land management plans have to address present and future cutting practices, landscape aesthetics, cultural resources, wildlife resources, wetlands, and rare or endangered species. The most difficult aspect of planning concerns the maintenance of multi-age stands of trees. These stands have great numbers of trees, especially seedlings, saplings, and poles that are more easily damaged than larger trees. The positioning of logging roads, landings, and small and large group cuts is crucial to the long-term success of silvicultural treatments. In turn, logging operation success is dependent upon careful advance planning (see Figure 9 for an example of silvicultural planning).

A well-planned harvest

FIGURE 9: HYPOTHETICAL EXAMPLE OF SILVICULTURAL PLANNING



This approximately 200-acre area of Division forest contains separate stands of white pine (WP), hemlock (HK), birch/maple (B/M), oak (OK), spruce (SP), and planted red pine (RP). A fire in 1957 severely burned the lower 1/3 of the area, and the red pine was planted shortly after this fire. The topography and hydrography of the area include large areas of well-drained sandy soils, but also several small steep areas, a year-round brook, a swamp, and a vernal pool (VP). These areas are delineated with buffers where required. Work within these areas is restricted; steep areas and muck soils are not worked, and buffers are only worked on frozen or dry ground. Fairy shrimp and mole salamander eggs have been found in the vernal pool, verifying its importance to wildlife. No work is proposed adjacent to this pool.

Except for the steep and wet areas, all the stands have received preparatory cuttings within the past 25 years, and the understory has developed in response. Additional work in this area will release advance regeneration by removing patches of overstory trees averaging 1 acre in size. Where understory species diversity is limited, further preparatory cuttings will occur, as well as enrichment plantings of appropriate species. Primary access is across the permanent road shown by a double dashed line. Single dashed lines are skidder and forwarder roads that have been used in the past and seeded and drained to prevent erosion. Landings are designated by a circled L, and represent areas used in the past and maintained as wildlife openings between operations. These roads and landings will be used again in current operations, and then returned to grass. There is evidence that the landings have been used between operations by wild turkey.

5.16.1.3 Operator Workmanship

Operator workmanship is one of the most crucial and variable factors in forestry operations. Good planning and preparation can be negated if operators perform poorly. Most loggers are paid on a piecework basis. Their paycheck does not always relate to how hard or how carefully they worked, but on the amount of wood that gets to the mill. However, the Division maintains tight control over loggers working on the watersheds, through close monitoring and through the timber harvest access permit and associated performance bond, and exercises its right to remove operators who fail to adhere to permit standards. It is important that foresters and loggers develop mutual respect that is based upon a shared commitment to the sustainable stewardship of the land for the protection of the drinking water supply.

5.16.2 Filter Strips

Filter strips are vegetated borders along streams, rivers, or water bodies (including vernal pools) and represent the final opportunity to prevent transport of sediment or nutrients into streams or reservoirs from nearby roads or landings. When roads and landings are near water resources, filter strips are given special attention. Chapter 132 (Forest Cutting Practices regulations) requires a minimum 50 foot filter strip, in which cutting is limited to 50% of the basal area and machinery is generally not allowed (exceptions include stream crossings).

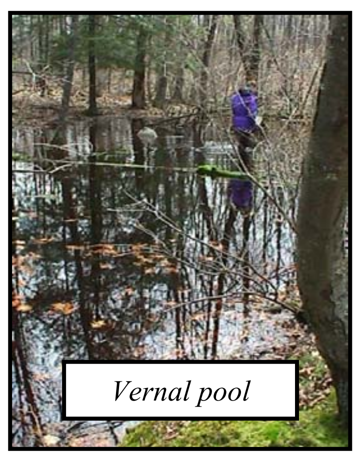
Chapter 132 regulations require increasing the filter strip based upon slope conditions and along Outstanding Resource Waters (protected public water supplies) and their tributaries, streams that are 25 feet or more from bank to bank, ponds of 10 acres or more, and designated scenic rivers. The Division meets these requirements and also increases the filter strip, based on both slopes and soils, for other areas not included in the definitions above. For example, on moderately and poorly drained soils the filter strip is increased 40 feet for each 10% increment of slope angle above 10%. On well-drained outwash and till soils the filter strip is increased 40 feet for each 10% increase in slope angle above 20%. Equipment may enter the filter strip in limited cases where streams must be crossed.

5.16.3 Buffer Strip

Buffer strips are retained and managed for aesthetic purposes along the edges of highways and public roads. Chapter 132 requires that within this strip, no more than 50% of the basal area can be cut at any one time and that no additional trees can be cut for five years. Buffer strips will be 50 feet except along designated scenic roads, where Chapter 132 requires them to be 100 feet in width.

5.16.4 Wetlands

The Division's forest management operations will comply with all the requirements of the Wetlands Protection Act, MGL ch. 131 section 40, and the Forest Cutting Practices Act MGL ch. 132 section 40-50 for cutting in wetlands (including bordering vegetated wetlands and freshwater wetlands as defined in the most current revision of Ch. 131 and 310 CMR 10.00, and as these are revised). Generally, activities that are not conducted under a Ch. 132 Forest Cutting Plan but will alter wetland resource areas (which include a 100 foot "buffer zone" beyond the water or the bordering vegetated wetland), are subject to approval through the filing of a Notice of Intent with the local conservation commission.


Vernal pool

All of the Division's silvicultural activities that involve wetland resources are conducted under a Chapter 132 cutting plan, supervised by both Division foresters and DCR service foresters, and therefore are exempt from Chapter 131 procedures. Exceptions include limited work that does not include harvesting, such as planting, pruning, and pre-commercial thinning, and maintenance of boundaries and fire breaks. All of these latter activities are defined as "normal maintenance of land in agricultural use" by Chapter 131, and are therefore exempt from its filing procedures.

Chapter 132 requires a 50 foot filter strip along all water bodies and Certified Vernal Pools, but allows harvesting in wetland areas provided that no more than 50% of the basal area is cut and the ground is only traveled by machinery when it will support that machinery (when it is frozen or dry). In addition, the Division does not allow machinery within low, flat wetland forest with muck soils that are seasonally flooded, even though statewide regulations allow work in some of these areas during frozen or dry conditions. Most of the muck soils on Division lands at Ware River are included within the designated wetlands on the watershed. The Division has identified and mapped most wetlands within the Ware River property, which are avoided when lot boundaries are drawn for proposed annual silvicultural operations. The Division also adheres to, or exceeds the statewide recommended practices for protection of vernal pools, providing a 15 foot no-cut buffer, a 50 foot no-machinery zone, a 100 foot shade zone, and a 200 foot low-ground disturbance zone (see Figure 10). This vernal pool protection is provided to all vernal pools, whether or not they have been certified.

5.16.5 Logging Practices

A primary purpose of CMPs is to prevent or minimize the movement of soil to the water resource. During a logging operation, this is most likely to occur on a landing or skid/forwarder road. In these areas, the humus layer is sometimes lost and the soils may be temporarily compacted and channelized so that water will flow over the surface instead of passing through the soil. If the road is unwisely placed on a continuous slope, rainwater will gather volume and velocity as it travels down-slope, scouring the path, removing soil, and creating a gully. If the road connects with a stream, the suspended soil may be carried much further. The result of careless logging practices can be erosion, increased stream turbidity levels, and deposition of the eroded materials downstream.

Logging practices and the human behavior necessary to avoid environmental degradation during logging are discussed in the following sections. A cutting plan still relies upon the judgment and common sense of the logger and forester to make the right decisions in order to protect the land and associated resources in a custom tailored, case-by-case manner.

A well-organized landing

FIGURE 10: TIMBER HARVESTING GUIDELINES NEAR VERNAL POOLS

Adapted from guidelines that were cooperatively developed by foresters and wildlife biologists in Massachusetts.

Vernal pools provide critical habitat for a number of amphibians and invertebrates, some of which breed only in these unique ecosystems, and/or may be rare, threatened or endangered species. Although vernal pools may only hold water for a period in the spring, the most important protective measure is learning to recognize these pool locations, even in the dry season. Foresters can then incorporate the guidelines below in their plans to ensure that these habitats thrive.

Vernal Pool and Depression and No-cut Area — 15 foot buffer around pool

Objective 1: Maintain the physical integrity of the pool depression and its ability to hold seasonal water.

1. Keep heavy equipment out of the pool depression at all times of the year. Rutting here could cause the water to drain too early, stranding amphibian eggs before they hatch. Compaction could alter water flow and harm eggs and/or larvae buried in leaf litter at the bottom of the depression.
2. Prevent sedimentation from nearby areas of disturbed soil, so as not to disrupt the pool's breeding environment.
3. Keep tops and slash out of the pool depression. Although amphibians often use twigs up to an inch in diameter to attach their eggs, branches should not be added, nor existing branches removed. If an occasional top lands in the pool depression leave it only if it falls in during the breeding season and its removal would disturb newly laid eggs or hatched salamanders.
4. Cut no vegetation within 15 feet of the high-water mark of the pool depression. Silvicultural manipulations are limited to girdling (for instance, to enhance vigor of uncommon swamp white oak trees).

Shade Zone — 100 foot buffer around pool edge

Objective 2: Keep a shaded condition in this 100-ft.-wide buffer around the pool depression. Amphibians require that the temperature and relativity humidity at the soil surface be cool and moist.

1. No equipment is allowed to operate within 50 feet of the pool edge.
2. Light, partial cuts that can maintain this microclimate are acceptable; clear cuts are not.
3. Understory vegetation such as mountain laurel, hemlock, advance regeneration or vigorous hardwood sprouts after a harvest will help to maintain this condition. Avoid leaving only trees with small or damaged tops, or dead and dying trees.

Objective 3: Minimize disturbance of the forest floor.

1. Operate in this area when the ground is frozen and covered with snow, whenever possible. Keep equipment 50 feet away from the pool depression and winch out logs or wood cut in this first 50 feet.
2. Avoid operating during muddy conditions that would create ruts deeper than 6 inches. Ruts can be an impediment to migrating salamanders, some of which are known to use the same vernal pools and migratory routes for 15 to 20 years.
3. Minimize disturbance of the leaf litter and mineral soil that insulate the ground and create proper moisture and temperature conditions for amphibian migrations.

Low Ground Disturbance Zone — 100-200 feet from pool edge

Objective 4: As above, minimize disturbance of the forest floor in this area.

1. Operate equipment in this area when the ground is frozen or covered with snow, whenever possible.
2. Follow 2 and 3 from objective 3 above.
3. Locate landings and heavily used skid roads outside of this area. Be sure any water diversion structures associated with skid trails and roads do not connect to or cause sedimentation in the shaded zone or the vernal pool itself.

5.16.5.1 Landings

When determining placement and layout of landings, their size and number are minimized and they are located on soils that will support the logging equipment. Landings are permanent sites and are placed on level and well-drained ground whenever possible. Frozen soils are desirable because they support heavy trucks, but these conditions cannot be assumed to occur for more than a month or two each year. When located on moderately drained soils, landings are constructed with natural and/or man-made materials that prevent rutting and maintain a workable surface. This generally includes the use of crushed gravel, which allows water infiltration and supports heavy equipment, and may also include the use of "geo-textiles," woven road construction fabrics that prevent mixing of gravel with the soils below. Landings will not be accessed by skidder or forwarder roads that direct water into the landing. An effective barrier is maintained between the landing and access road (e.g., road ditch, hay bales) and landings are required to be smoothed and seeded after use. Also, to prevent inappropriate uses of landings, for instance as access points for illegal off-road or all-terrain vehicle use, the access to landings from adjacent roadways will be blocked with logs, stones, or a locked gate if necessary.

5.16.5.2 Skid Roads

Skid roads are designed to be reused and are therefore located on soils that can support the skidder, such as well-drained gravel or well-to-moderately-drained stony till soils. Some soils, regardless of their drainage capacity, are wet in the spring, early summer, and late fall and harvesting must be scheduled for dry or frozen conditions. Skid roads are cut out before use and limbs left in the road to protect the soil. Skid roads are relatively straight to avoid damaging roadside tree stems and roots, but they are not allowed to carry water for more than 100 feet. Continuous grades are deliberately interrupted to divert rainwater off the road. Most skid road grades are less than 10%, but in some cases, climbing grades may reach a maximum of 20%. These steeper climbing grades are limited to 200 continuous feet. Downhill skidding grades are allowed up to 30% but for no more than 200 feet on grades greater than 20%. On skidding grades greater than 20%, which are not protected by frozen ground or snow cover, tree branches will be put on the road and other erosion-control measures taken as necessary.

Skidding distances are minimized to prevent excessive wear to roads unless frozen ground, snow, or rocks protect them. Skidder width and weight requirements are tailored to site conditions. The Division has rated many commercially available skidders by taking into account their horse power, weight, load capacity, tire size, and width to determine their suitability for logging on water supply watersheds (see Table 9 for examples). Skidder width ranges from 85-114 inches and loaded ground pressures range from 5-11 lbs/sq. inch. Typically, machines with loaded ground pressures of 8 lbs/square inch or less and widths of 102 inches or less are allowed on Division watersheds. Skidding is stopped when rains or thaws make the soils unable to support skidders.

At the end of the logging operation or when work is suspended, efforts will be made to prevent access by unauthorized vehicles (such as ATV or other off-road vehicles) by blocking access with boulders, logs, or, if appropriate, locked gates. Skid roads are also stabilized to prevent erosion following the completion of the operation. The construction of water bars accomplishes this task. On slopes greater than 10%, water bars are spaced every 50 feet and on slopes less than 10%, they are spaced every 100 feet. It is sometimes difficult to regularly space water bars due to rocky conditions and lack of places to discharge water, so spacing may vary. Water bars are designed to meet two criteria:

- They must angle across and down the road to create a 3-5% pitch.
- They must discharge water to an area that drains away from the road.

A skidder can usually be used to construct water bars unless the soils are very rocky or ledgy. In rocky soils, they may have to be dug by hand. They do not have to be more than 6-8 inches deep, including the berm, unless they have to deflect more than the overland flow off skid roads (in which case depths are doubled). After completion of logging, water bars on skid roads are seeded during the growing season.

5.16.5.3 *Forwarder Roads*

Forwarder roads are located on soils that can support these machines. The layout of forwarder roads is more flexible than for skid roads because forwarders do not require straight roads. Forwarder roads can pass through the forest avoiding soft soils, trees, and sloping ground. Forwarder roads usually have less than a 5% slope with an occasional grade up to 10% for a maximum of 100 feet. Forwarder roads sometimes require rough preliminary grading to remove stumps and rocks. Forwarders were originally designed to stay on the road and pick up logs brought to the road by a skidder, but they also replace skidders when soil and/or vegetation conditions and cultural features cannot accommodate skid roads and skidder landings. In operations that combine skidders and forwarders, skidders operate the sloping and rough ground for distances of less than 1,000 feet, while forwarders operate on the more level terrain and handle long hauling distances. Water bar requirements for forwarder roads are the same as for skid roads, and unauthorized access to these roads will be blocked following the completion of the operation.

5.16.5.4 *Stream Crossings*

Division forestry operations cross streams on a limited basis. For example, from 1978 to 1990, the Division conducted 130 logging operations on the Quabbin and Ware River watersheds that involved twelve stream crossings. Seven of these twelve were across existing culverts, two were mitigated with approved methods, and three were crossings of intermittent streams in dry or frozen conditions. Stream crossings are frequently avoidable on Division watershed properties because the size of the property holdings often makes it possible to access a given stand from several directions. Frozen conditions are favored whenever streams must be crossed. These conditions not only protect the actual crossing but also protect the approach and limit the amount of soil carried in machine tires or on skidded logs.

Portable bridging is used to cross all streams with a continuous flow. This bridging consists of either pre-fabricated sections transported to the site (the Division has constructed portable bridge sections for use by private timber harvesters) or site-constructed bridging. Past studies (Thompson and Kyker-Snowman, 1989) have shown that machine placement and removal of crossing mitigation can move substantial sediments into the stream, especially where banks are steep or unstable. It may be preferable in some conditions to construct mitigation on-site and without machinery. In either case, the bridging will be designed and constructed so as to prevent degradation of stream water downstream of the logging activity before, during, and after that activity.

Correct siting of crossing locations is important in order to avoid soft soils that the machine may carry onto the bridge and into the water. Chapter 132 requires that all crossings be marked with paint or flagging and carefully mapped prior to filing of a cutting plan. All crossings are made at right angles to the streamflow. If frozen conditions are not available, then banks and adjacent soils are protected with tops of trees, poles, or other suitable material. In all crossings, any mitigation that involves structures that obstruct streamflow is designed and installed to accommodate the 25-year stormflow for the upgrade drainage. All temporary crossing construction is removed at the completion of the operation, and the site stabilized. Division foresters supervise the design, construction, placement, and removal of bridging or other mitigation and the proper protection of approaches, prior to the commencement of logging on the site.

Crossings of small, intermittent streams subject to MGL ch. 131-132 protection (those portions downstream from the highest bog, swamp, wet meadow, or marsh in the drainage) are mitigated to prevent measurable downstream water quality degradation when these streams are flowing. These streams are only crossed without mitigation during frozen or dry conditions (when they are not flowing). No intermittent stream crossing will be allowed that would result in rutting or disruption of stream bank integrity. Chapter 132 further requires that all streams within 1,000 feet of the reservoir high water mark, including intermittent streams downstream of the highest wetland, must be crossed with portable bridging. Division foresters will monitor all unbridged crossings frequently and discontinue or mitigate them if conditions deteriorate and downstream water quality is threatened.


Skidder on a temporary bridge

Table 11 outlines the various stream-crossing situations encountered on Division watersheds and level of protection these crossings are given.

TABLE 11: PROTECTION MEASURES APPLIED TO VARIOUS STREAM CROSSING SITUATIONS

	Level of Protection		
Type of Crossing Situation	CMPs Only	Mitigate	Bridge
Intermittent stream, above the highest wetland in the drainage.	√		
Intermittent stream, downstream of highest wetland, when not flowing; crossing further than 1,000 feet from reservoir high water mark.	√		
Intermittent stream, downstream of highest wetland; crossing further than 1,000 feet from reservoir high water mark; when flowing.		√	
Any intermittent stream with unstable banks/approach; regardless of flow conditions.		√	
Intermittent stream, downstream of highest wetland, crossing within 1,000 feet of reservoir high water mark; regardless of flow conditions.			√
Continuously flowing stream.			√

Key: "Wetland" refers to bogs, swamps, wet meadows, and marshes. "Mitigate" includes use of poles, brush, or slabs placed in or beside a small stream to minimize equipment impacts on bank or streambed integrity. "Bridge" includes installed or site-built structures that are above the stream profile and capable of keeping all equipment and harvested products out of the profile.

5.16.6 Pollution Control

This section describes methods for control of petroleum product spills, human waste, and the disposal of rubbish generated by loggers and logging machinery maintenance.

Petroleum products: All machines are inspected by Division foresters for leaks prior to arrival and for the duration of their stay on the watershed. Checks are made of all hydraulic components, fuel tanks and lines, engine, transmission and axles. Trucks, forwarders, skidders and other equipment that carry petroleum products must have a minimum of 6 petroleum-absorbent pads (3'x 3') on the machine. Immediate action to contain and stop any petroleum spills followed by prompt notification of the forester is required. The forester in turn contacts Division Environmental Quality personnel.

All petroleum products that are not in machine storage are stored in safe durable containers and removed from the watershed at the completion of each day. Petroleum storage is only allowed in tanks designed, manufactured, inspected, and certified for commercial use. No re-fueling or servicing is allowed within the 50 foot filter strip along water bodies or within 25 feet of any wetland.

Human waste: Deposition of human solid waste is not allowed on the watershed. Permit specifications require the use of a portable bathroom facility (a minimum of a “Coleman” chemical toilet). The only exception to this policy will be the use of existing sanitary facilities on the watershed, which include those installed for recreational access.

Rubbish: All waste material, including parts, packaging, lubricants, garbage, sandwich wrappers, and other litter must be stored in appropriate containers and removed daily from the watershed.

5.16.7 Fire Prevention

Fire prevention concerns both the forest and machinery. MGL ch. 48, s. 16, a.k.a. the “Slash Law,” adequately deals with the disposal of slash along boundaries, water bodies, wetlands, highways, roads and utility right-of-ways. Slash is not allowed within 25' of any stream, river, pond or reservoir. This law is also the Division standard.

Machine fires can spread to forest fires and cause water and soil pollution. Keeping a leak-free, well-maintained machine and having the proper fire extinguishers on the machine can prevent damaging machine fires. All machines are inspected for proper fire extinguisher and spark arresters by a Division forester before entering the site.

5.16.8 Protection of Residual Vegetation

Avoiding damage to roots, stems, and crowns of understory and overstory vegetation is essential in maintaining a protection forest. Damage can occur from unskilled tree felling, skidding, forwarding and the development of skid/forwarder roads. Skilled loggers and foresters can prevent most damage if the proper logging system is used. Division permits include the right to suspend operations due to operator inexperience or negligence.

5.16.9 Cultural Resource Protection

The protection of cultural resources fits well with watershed protection forestry because they both require low-impact logging systems. For example, small versatile equipment can reduce soil compaction and work around walls and foundations without damage. In many locations, there are no places for a landing due to cultural sites or poor soil conditions. Forwarders mitigate this problem by stacking logs on the roadside. The preferred logging system in these situations is a combination of cutting, lifting, or winching trees out, and forwarding them to an appropriate landing to meet cultural resource protection objectives (see Section 8 for a more detailed discussion on this subject).

5.16.10 Aesthetics

Aesthetics can be affected by all of the practices described in the above sections, and are the demonstration of quality workmanship. The maintenance of aesthetics reflects how the logger feels about the work and the land on which it is taking place. This perspective cannot be forced, but it can be encouraged and learned. When work is done correctly it is less conspicuous, but when it is done carelessly, it is obvious to all. These are public lands and the public regularly passes through them either along public roads or on roads within the watersheds. Attention to aesthetics is important everywhere, but most important along traveled ways. All slash and debris from fallen trees is kept 20’ back from the road’s edge or on the backside of a bordering stone wall. Landings are cleaned of unmerchantable tree debris. Care is taken to maintain large roadside trees and to promote replacement trees.

5.17 Control of Harvest Operations through Timber Sale Permit

In conducting silvicultural operations that require the removal of forest products from the forest, Division policy is to protect water quality as well as watershed resources such as soils, residual trees, and cultural resources. The Chapter 132 Forest Cutting Plan, the Division timber sale permit (discussed below), and the Conservation Management Practices presented in the preceding section address these concerns. In general, the timber sale permit specifies the performance standards, whereas the CMPs explain how these permit specifications are met.

The Permit consists of written specifications, pages detailing the forest products offered for sale, maps delineating the sale area, and a proposal page where a bid for the timber is entered and signed. The written specifications deal most directly with protecting watershed resources. Specifications consist of four parts: a.) General Conditions, b.) Water Quality Specifications, c.) Harvesting Specifications (including utilization, silviculture, and equipment requirements), and d.) Bidding and Bond Specifications. Parts b. and c. pertain to protecting watershed resources.

5.17.1 Water Quality Specifications

Water quality specifications are primarily concerned with petroleum leaks and spills and control of human waste. Petroleum products are required to be kept in suitable containers and removed from the work site each day, unless stored in tanks designed for fuel, such as those on the logging equipment. Oil absorbent pads and blankets are required on site and with all equipment, in order to intercept and immediately control a petroleum spill, should one occur. All associated refuse from maintenance and repair is required to be stored in appropriate containers and removed from Division lands as soon as possible. Human waste is required to be deposited in Division toilets or toilets supplied by the operator.

5.17.2 Harvesting Specifications

Harvesting specifications are concerned primarily with the process of cutting trees and removing forest products from the forest. Division timber harvesting permits specify conditions for lopping slash to enhance decomposition and reduce fire hazards. Specifications are described for keeping slash out of streams and back from access roads. The penalty for cutting unmarked trees is set at three times the value of the tree. Utilization standards are specified in each permit in order to limit slash (by indicating the maximum diameter of slash that may be left in the woods). There are also specifications to limit damage to residual trees and soils, especially in the felling and removal of forest products. Locations for logging roads and landings are determined by the Division forester and delineated in the field and on the approved cutting plan; the permit specifies the condition in which these areas must be left at the completion of the operation. The permit makes it clear that the logging operation may be suspended due to wet or extremely dry conditions, at the forester's discretion.

Equipment specifications limit the size of skidders and other equipment to minimize soil compaction and rutting and to minimize physical damage to residual trees and cultural resources. These specifications may require specific equipment due to the conditions of the lot. For instance, where it is difficult to place straight skid trails, or where dense regeneration is present, the forester may specify that a forwarder must be used and that skidders are not allowed. Where hauling distances to a truck landing are long, but the lot itself requires skidding, the forester may require that both pieces of equipment must be used. The Division also may require a tracked feller-buncher-processor on lots that have sensitive cultural resources requiring specialized tree removal, on soils that cannot support heavy equipment, or in stands with heavy forest stocking that cannot be thinned properly with standard equipment.

5.18 Internal Review and Monitoring of Forest Management Operations

The key to the proper protection and management of the resources under the care and control of the Division is its staff, and the care and expertise they bring to their work. Because the foresters walk each acre of land on which forest management occurs, the management controls enforced by this staff are of paramount importance. As the on-the ground implementers of the Division's land management plans and policies, the foresters' knowledge of, and sensitivity to the various aspects of the watershed management plan have a direct bearing on the ultimate success of the program. However, it is impossible for any one individual to assimilate all aspects of the diversity of knowledge in the evolving fields of natural and cultural resource management. Therefore, the second key to implementing sensitive management is in-house review by specialists in the various key disciplines of study in natural and cultural resources, and effective communication between these specialists and the forest managers.

Within the Division, these supporting disciplines include wildlife biology, forest planning, water quality and environmental engineering, civil engineering, and cultural resource protection. Experts available outside the Division include rare species botanists and zoologists (Massachusetts Natural Heritage and Endangered Species Program) and cultural resources specialists (Massachusetts Historic Commission). The Division also has available a wide variety of experts conducting academic research on the watersheds at any given time, in part because of the research value of the resources under the Division's care and control. These professionals and interested non-professionals who spend time studying and exploring the watersheds, contribute invaluable observations that complement the Division's understanding of its watershed resources.

To efficiently and effectively coordinate and focus this collective knowledge towards the improved protection of the drinking water supply and other natural and cultural resources, the Division has developed the following procedure for the annual review of all proposed Division forest management activities on the Ware River watershed. These reviews are in addition to the general guidelines for cultural and wildlife resource protection.

- Each December, the Division's foresters compile a plan of all proposed forest management that could occur during the next fiscal year (July-June). The only operations not included are emergency salvage after natural events. Each January, the foresters carefully map and describe the boundaries of each planned operation so that they are readily distinguishable on the ground (where boundaries are not easy to describe, they are marked with flagging). These outer boundaries may include internal areas where logging is restricted (vernal pools, stream filter strips, etc).
- After mapping the areas where forest management is proposed, the foresters submit site maps and complete forms describing the proposed silviculture in detail to the Division Natural Resource Section. Natural Resources staff digitize the maps of the planned operations, which include proximal wetlands and previously identified critical cultural and wildlife sites, prepare area summaries of these operations, and check the overall consistency of the operations with management plan silvicultural and resource protection objectives. After reviewing the proposed operations, Natural Resources then forwards copies to the watershed Superintendent, the DCR archaeologist, and the Division wildlife biologist.
- In 1986, 1990, and 1994 consultants compiled cultural resource maps for Division watershed properties. These maps denote known and likely historic sites. This identification process has not yet occurred for the Ware River watershed, although a proposal is being considered to continue this work. Once these resources are identified, and where forest management is planned for areas containing or likely to contain cultural resources, the Chief Archaeologist will identify types of activity that could damage these resources, such as soil compaction or disruption of existing structures such as walls or foundations. The Chief Archaeologist may also make recommendations for removing trees that threaten existing historic structures, and identifies areas of high, moderate, or low probability of containing prehistoric occupation sites. With these concerns in hand, the foresters modify timber-harvesting approaches as needed to protect these resources.
- Each spring, the Division's wildlife biologist reviews the planned forest management operations. Where necessary, the wildlife specialist conducts site examinations. Landscape level wildlife changes over long time spans will also be tracked using an evolving set of techniques. Local knowledge of state rare, endangered, and threatened species is referenced, as well as the location of any critical or important habitat features in the wildlife biologist's files. After completion of fieldwork by the wildlife specialist, the foresters are alerted to any potential conflicts between the proposed work and important habitat features, keyed to flagging on the ground where necessary. Specific wildlife Conservation Management Practices are outlined in Section 6 of this plan.
- Each spring, the Division's Environmental Quality staff reviews the planned forest management and, where necessary, conducts site examinations. The Environmental Quality staff may give site-specific guidelines regarding special precautions designed to increase the protection of site water quality.

- In 1995 and 1996, the Division contracted with a professional botanist to review all proposed Division lots for the presence of rare or endangered plant species. The bulk of this plant inventory occurred during May and June, although the botanist made preliminary recommendations pending an additional survey for late flowering species, conducted in August, for a limited number of these operations. In the final reports, the botanist made specific conservation management recommendations to protect these plant populations.
- Where the review process identifies undesirable potential impacts, the foresters consult with the reviewers to design a practical solution. If there are any changes in the area to be harvested and/or in the proposed practices, the forester is responsible for notifying the Natural Resources Section in order to determine if further review is required by the changes. Once the review process is complete, the foresters lay out and mark the harvesting lots. At this time a Forest Cutting Practices Act (MGL Ch. 132) Cutting Plan is prepared (outlining skid roads and specific site impacts), which the logger is required to follow. The Forest Cutting Plan is submitted to the DCR Bureau of Forestry and copied to the local Conservation Commission. After the lot has been advertised and awarded to a private timber harvester, Chapter 132 requires DCR/DSPR staff to conduct a site visit prior to the start of the operation if wetland resources are involved. These regulations also require that DCR Service Foresters check all cutting plans against the Natural Heritage maps of rare and endangered species habitats and, if they overlap, submit these plans to Natural Heritage for review and comment.

Throughout the active operation, it is the responsibility of the forester in charge to continuously monitor compliance with water quality protection measures. In particular, these include stream crossings and work near wetlands, conditions of skidder and forwarder roads as well as main access roads, equipment maintenance, and the treatment and placement of slash. The Division "Permit to Harvest Forest Products" includes detailed specifications for each harvesting operation. During the operation, the Division reserves the right to suspend the harvesting activity if warranted by weather, soil, or wildlife conditions. Upon completion of silvicultural operations, it is the responsibility of the foresters to check for full compliance with all timber harvest permit specifications prior to the release of the performance bond and filing of final reports.

Note: a separate review process is required for proposed access road development or the opening of new gravel operations. For details of this process, see Section 4.3.3.3.

6 Wildlife Management

6.1 Overview of Ware River Watershed Wildlife Community

All species of wildlife depend on the existence and quality of various habitat types. Some species require very specific habitats to survive (e.g., wood frogs and vernal pools), while other species, such as coyote can exist in a variety of habitats. The Ware River watershed is comprised of a mosaic of habitats. Division-controlled land within the watershed is largely forested, while privately owned lands include small farms, fields, woodlots, and residential areas. Although as a whole the landscape is fragmented, Division-controlled land within the watershed is extensive and relatively contiguous. The undeveloped and relatively unfragmented nature of these lands is of tremendous benefit to wildlife species that require large tracts of habitat.

The Ware River watershed supports an impressive array and abundance of wildlife. Division forests provide habitat for a diversity of birds and mammals including moose, white-tailed deer, turkey, grouse, fisher, and bears. Neotropical migratory birds – including black and white warblers, rose-breasted grosbeaks, and scarlet tanagers – also utilize Division forests for breeding and as migratory rest stops. The Ware River watershed is dotted with wetlands, streams, and beaver ponds that support a variety of reptiles, amphibians, and birds. There are several multi-acre tracts of early-successional non-forested habitat within the Ware River watershed that provide habitat for species dependent on open lands, including eastern meadowlarks, bobolinks, and various insects.

One of the most important qualities of Division land in the Ware River watershed is its protection from development. Some towns within the watershed are experiencing tremendous growth, and as a result open space is being rapidly converted to residential or commercial uses. The protection that Division lands provide to wildlife species is critical to their long-term survival.

Several wildlife species are monitored by Division personnel or other agencies. For example, a yearly ruffed grouse survey is conducted each spring. In addition, permanent breeding bird surveys are conducted as part of a national effort. A new survey was begun in 2002 by Division staff to monitor moose populations within the watershed. Finally, data on vernal pools is collected each year.

While a great deal of information about certain wildlife taxa such as birds and mammals is available from surveys and observations, very little is known about other Ware River wildlife. A complete species list does not exist, and there is a paucity of information about reptiles, amphibians, insects, butterflies, dragonflies, and other more secretive species. It is quite probable that Division lands within the Ware River harbor state listed species that have yet to be documented.

6.2 Wildlife Management Goals and Objectives

The primary goal of the wildlife program on the Ware River watershed is to protect water quality from negative impacts associated with wildlife (for instance, preventing the distribution of pathogens that can be passed from wildlife to humans). Beyond water quality protection, the goals of the wildlife program are to protect important wildlife and their habitats while minimizing or eliminating adverse wildlife impacts on other watershed resources. In certain circumstances, active management to enhance wildlife habitat may occur. The specific objectives of the wildlife management program are to:

- MITIGATE ADVERSE IMPACTS OF WILDLIFE ON WATER QUALITY, INFRASTRUCTURE, AND OTHER WATERSHED RESOURCES.
- PROTECT UNCOMMON, RARE, AND OTHERWISE SIGNIFICANT WILDLIFE SPECIES AND HABITATS WHEREVER THEY EXIST ON DIVISION LANDS.
- ASSESS AND MITIGATE IMPACTS OF WATERSHED MANAGEMENT ACTIVITIES ON WILDLIFE THROUGH A PROCESS OF NOTIFICATION, SITE VISITS, REVIEW OF RECORDS AND LITERATURE, AND RECOMMENDATIONS TO APPROPRIATE MANAGEMENT STAFF.
- ACTIVELY MANAGE FOR SELECTED WILDLIFE SPECIES THAT ARE CONSIDERED TO BE COMMON, RARE, OR UNIQUE ON A REGIONAL OR STATEWIDE BASIS.

Certain wildlife species within the Ware River watershed can negatively impact both infrastructure and other critical resources in certain areas. Mitigating these impacts will be a top priority.

Although the focus of this plan is the protection of water resources, the Division recognizes that its land management activities may impact certain wildlife species or habitats. It is a Division goal to avoid adversely impacting significant wildlife species or their habitats. This will be accomplished primarily through inventory and survey work to locate rare species and habitats, proper coordination with MassWildlife's Natural Heritage and Endangered Species Program, and proper precautions using management guidelines and Conservation Management Practices (CMPs) in all timber harvesting and other management practices.

While directly protecting rare or endangered wildlife will be a priority, the Division recognizes that its management activities have the potential to impact more common wildlife. Another objective is to assess the impacts of these land management activities on the wildlife communities at the Ware River, and thereby minimize adverse impacts. This will be accomplished through long-term monitoring programs and an in-house review process for all planned management activities.

On certain portions of the watershed, it may be feasible and desirable to proactively manage the habitat for the benefit of wildlife. This level of land management is a step beyond habitat protection and is focused on either habitats or wildlife species that are rare or of special concern on a regional or statewide basis. Some activities might include prescribed burns to enhance a field or meadow, selective removal of exotic plants, erecting nesting platforms for certain species of birds, or creating brush piles or rock piles.

6.3 Conservation Management Practices (CMPs) for Wildlife Management

Division foresters are concerned primarily with maintaining water quality standards and improving forest health and vigor. Monetary gain from forest resources is a secondary consideration when planning forest management activities. A direct result of this flexibility is that it allows Division foresters to incorporate sound and beneficial wildlife management components into their forest cutting plans. For instance, high quality mast trees, active and potential den and nest trees, and critical habitats have been and continue to be conserved and even enhanced during silvicultural operations. Specific wildlife habitat management recommendations are described in detail below.

6.3.1 Vernal Pools

Vernal pools are contained basin depressions with no permanent outlet and typically hold water for at least 2-3 months in the spring and summer. Vernal pools may or may not dry completely each year, but their periodic drying, shallow water, winter freezing, low oxygen levels, and lack of a permanent outlet keeps them free of fish populations. Because of their unique characteristics, vernal pools play a critical role in the life cycles of many amphibians, reptiles, and invertebrates. As a result, the Division considers vernal pools to be critical wildlife habitats. In fact, many state-listed species are associated with or dependent on vernal pools. Many vernal pools dry completely during the late summer and fall and can be difficult to identify. In recent years, the Division has made efforts to locate and identify vernal pools during the spring. Accurate and detailed records of located pools, including UTM coordinates, physical characteristics and animal use, are stored in Division databases. In addition, the University of Massachusetts recently identified over 400 "potential" vernal pools on the Ware River watershed through aerial photos. These locations have been digitized, and in the future, will be field checked to determine their support for breeding. Locations of both potential and documented vernal pools have been transferred to a GIS datalayer for inclusion in land management planning documents.

Research is currently being conducted at Quabbin Reservation to test the effectiveness of Massachusetts Best Management Practices for vernal pools. While the state BMPs provide direct protection of the pool, there is concern that the wildlife species utilizing the pool may also rely on a larger area surrounding the pool for a majority of their life cycle. This research will test the effectiveness of the current BMPs.

Vernal Pool Management Objectives: DCR/DWSP is working to locate and identify all vernal pools on Division property and to avoid adverse impacts to vernal pool depressions and adjacent habitat.

Recommended Practices for Vernal Pools:

- Seek additional input from NHESP when management activities are going to occur around a pool that contains state-listed species.
- Digitize all aerially interpreted vernal pools and provide the datalayer to GIS personnel for inclusion in land management activity plans.
- Identify and confirm breeding use in photo-interpreted vernal pools.

Within Pool Depression:

- Maintain physical integrity of pool depression and its ability to seasonally hold water.
- Keep depression free of slash, treetops, and sediment from forestry operations. If slash does fall into pool during the breeding season do not remove it so breeding activity is not disturbed.

Edge of pool:

- Keep shaded condition in 100-foot buffer around pool depression.
- Minimize disturbance of forest floor within 200 feet of pool edge.
- Avoid making ruts >6 inches deep within 200 feet of pool.
- Conduct low-intensity harvests preferably when ground is frozen.

6.3.2 Seeps

Woodland seeps tend to be small (< ¼ acre) areas where ground water flows to the surface of the forest floor and saturates the soil. Seeps generally don't freeze during the winter and typically have little or no snow cover. Seeps often occur in natural depressions and may act as "seed traps" in which nuts, seeds, and fruits from surrounding trees and shrubs accumulate. This makes them important winter feeding sites for turkey, deer, and other wildlife.

Seeps provide a seasonally important source of food and water for resident and migratory wildlife (Hobson et al., 1993). These areas tend to have early sources of green vegetation, which can be an important food source for black bears in the spring and early summer. Earthworms and insects at seeps attract early migrants such as robins and woodcock. Spring salamanders and hibernating frogs, which can attract skunks and raccoons, may also use seeps.

Seep Management Objective: The Division will continue to protect seeps, springs, and surrounding soils.

Recommended Practices for Seeps:

- AVOID LEAVING SLASH IN WOODLAND SEEPS OR SPRINGS.
- MAINTAIN MAST-PRODUCING TREES ABOVE AND AROUND SEEPS.
- REMOVE CONIFER TREES ON SOUTH SIDE OF SEEP; RETAIN CONIFERS ON NORTH AND WEST SIDES.
- WHERE SEEPS ARE PRESENT, SCHEDULE HARVESTS TO OCCUR ON FROZEN GROUND OR DURING THE DRIEST CONDITIONS.
- AVOID RUNNING HEAVY EQUIPMENT WITHIN 50 FEET OF THE EDGE OF A SEEP.
- WHEN FEASIBLE, USE SEEPS AS THE CENTER FOR UNCUT PATCHES TO RETAIN CAVITY TREES, SNAGS, AND OTHER WILDLIFE FEATURES.
- IN STANDS WHERE SEEPS ARE PRESENT, LAY OUT SKID TRAILS AND ROADS PRIOR TO HARVEST, WHEN SEEPS ARE OBVIOUS.

6.3.3 Orchards

Abandoned apple orchards and scattered fruit trees exist on Division property. Wild apple trees are one of the most valuable wildlife food species in the Northeast (Elliot 1988, Tubbs et al., 1987, Hobson et al., 1993). White-tailed deer, grouse, squirrels, fox, fisher, porcupine, and rabbits will eat apples or apple seeds. Apple trees also provide nesting and perching habitat for bluebirds, flycatchers, robins, orioles, and sapsuckers (Elliot 1988). Apple trees in abandoned orchards eventually become crowded by invading shrubs and over-topped by the encroaching forest. Prolonged crowding and shading will lead to decreased vigor and eventually death.

Orchard Management Objective: The Division will save apple and other fruit trees when possible and increase their health and vigor when feasible.

Recommended Practices for Orchards:

- CONTINUE TO IDENTIFY ABANDONED ORCHARDS AND CLUSTERS OF FRUIT TREES, AND IF POSSIBLE, RETAIN ALL FRUIT TREES.
- WHEN FEASIBLE, REMOVE ALL BRUSH AND SHRUBS UNDER THE DRIP LINE OF THE FRUIT TREE.
- IF THE FRUIT TREE IS SHADED BY LARGE OVER-TOPPING TREES, REMOVE ALL COMPETING TREES, LEAVING THE FRUIT TREE IN AN OPENING.
- WHEN POSSIBLE, PRUNE, LIME, AND FERTILIZE TREES AT LEAST EVERY 3 YEARS.

6.3.4 Wildlife Wintering Areas

Wildlife wintering areas (WWA) provide shelter and food for animals during the winter months when cold temperatures, snow cover, and limited food resources create physiologically demanding conditions. Deer wintering areas (DWA) typically are in hemlock or pine stands where there is >70 percent conifer crown closure (Elliot 1998). Deer typically move to these areas when snow depths are around 12” (Flatebo et al., 1999). DWA provide reduced snow depths, higher nighttime temperatures, reduced wind, and greater relative humidity (Flatebo et al., 1999). The best DWA not only provide adequate cover, but also a quality supply of deer food. Cedar, red and sugar maple, birch, and hemlock are preferred foods. Another important WWA is dense conifer cover such as spruce stands that provide increased thermal protection and wind cover for a variety of birds and mammals. For example, grouse will seek conifer stands for thermal protection when snow depths are <8".

The general guideline for wildlife wintering areas is to maintain as much overstory as possible, while providing for the establishment and continued growth of preferred browse and conifer tree species.

Wildlife Wintering Areas Management Objective: The Division will maintain the functional value of wildlife wintering areas.

Recommended Practices for Wildlife Wintering Areas:

- IDENTIFY AND MAP ALL KNOWN OR POTENTIAL WWA USING AERIAL PHOTOS, COVER TYPE MAPS, AND FIELD INSPECTIONS.
- WHEN FEASIBLE, SCHEDULE FOREST HARVEST OPERATIONS DURING DECEMBER-APRIL NEAR WWA SO TREE TOPS ARE AVAILABLE FOR BROWSE.
- PROTECT ADVANCE CONIFER REGENERATION DURING TIMBER HARVEST.
- CUT STUMPS LOW TO ENCOURAGE VIGOROUS SPROUTING.
- PLANNED ACTIVITIES WITHIN WWA SHOULD BE CONDUCTED TO ENSURE THAT AT LEAST 50% OF THE WINTERING AREA REMAINS IN CLOSED CANOPY CONIFEROUS OVERSTORY TO PROVIDE FUNCTIONAL SHELTER.
- AVOID CONCENTRATING HARVEST IN ANY ONE AREA OF THE WWA.
- TRY TO MAINTAIN TRAVEL CORRIDORS (UNBROKEN, DENSE SOFTWOOD COVER 60-100M WIDE) THAT CONNECT ALL PORTIONS OF THE WWA.

6.3.5 Mast

Mast is a critical component of quality wildlife habitat. Trees, shrubs, and vines produce fruits, nuts, and berries called mast. Mast can be hard (nuts, seeds) or soft (fruit, berries). It contains more fat and protein than other plant foods and is actively sought by a variety of birds and mammals. In autumn, mast is particularly important as many animals will focus on eating mast in preparation for winter. Bears, squirrels, raccoons, deer, and turkey will fatten up on acorns, beechnuts, and hickory nuts. Resident songbirds such as nuthatches, chickadees, and bluejays rely on mast during winter when other food is scarce. Migrating birds will often rely on fruits and berries during migratory stops to replenish energy.

Although all trees and shrubs are defined as mast producers, some species are more important to wildlife. The value of mast to wildlife differs with the size, palatability, accessibility, nutritional content, abundance, and production frequency (Flatebo et al., 1999). In general, oak, hickory, beech, walnut, butternut, cherry, ash, and conifers are the most important mast trees. In addition, birch, hazel, alder, and aspen are also important to some wildlife species.

6.3.5.1 Hard Mast

At the Ware River, red, white, black, and scarlet oaks are the most important source of hard mast. Hickories and beech comprise a relatively small component (2%) of the overstory. Oaks are probably the most important wildlife mast trees in the northeast. Acorns are eaten by over 100 species of birds and mammals (Healy 1997). The frequency and characteristics of oak production varies from species to species. Red oaks produce a good crop of acorns every 2-5 years, black oaks every 2-3 years, and white oaks every 4-10 years. Red and black oak acorns take 2 years to develop, while white oaks take only 1 year. Peak acorn production begins at around 25 years for red oaks, 40 years for white oaks, and 40-75 years for black oaks (Flatebo et al., 1999). White oak acorns contain less tannin and may be more palatable to wildlife.

Beech and hickory trees comprise a smaller component of the Ware River watershed forest. Hickories are scattered around the watershed, usually interspersed with oaks. They have good seed crops every 1-3 years and begin producing quality crops at 40 years. Hickory nuts have one of the highest fat contents of any mast. Beech trees occur irregularly across the watershed. The prevalence of beech bark disease and low market demand has shifted attention away from this species. However, beechnuts can be an important source of food for a variety of wildlife. Wild turkeys prefer beechnuts to all other mast (Williamson undated).

The seeds of maples, birches, ashes, and conifers provide food for many birds and small mammals. Red squirrels rely heavily on conifer seeds and their populations will fluctuate in response to annual crops. Birches are an important mast producer because most of the seed crop is retained on the tree above the snow. Birds, including pine siskins and grouse, rely heavily on birch seeds for their winter diet. White and red pines are the most widely distributed conifers at the Ware River. Mice, voles, grosbeaks, and finches are a few of the animals that utilize conifer mast. Chickadees and goldfinches prefer hemlock seeds.

6.3.5.2 Soft Mast

Black cherry trees comprise a relatively small percentage of the Ware River watershed forest canopy. However, bears, small mammals, and over 20 bird species eat cherries (Flatebo et al., 1999). Pin and chokecherries are short-lived, but provide valuable fruit to wildlife. A variety of understory shrubs and trees produce soft mast. Blueberries, serviceberries, dogwoods, and viburnums are abundant. In addition, herbaceous plants such as blackberry, raspberry, wild strawberry, and partridgeberry are utilized.

Mast Management Objective: The Division will continue to maintain and encourage a variety of mast-producing plants within the watershed.

Recommended Practices for Mast:

- MANAGE FOREST STANDS TO CONTAIN MULTIPLE SPECIES OF MAST-PRODUCING TREES AND SHRUBS.
- RETAIN PRODUCTIVE BEECH, OAK, AND HICKORY TREES WHEN THEY OCCUR AS SINGLE OR SCATTERED TREES IN STANDS DOMINATED BY OTHER SPECIES.
- RETAIN BEECH TREES WITH SMOOTH OR BLOCKY BARK OR RAISED LESIONS TO PROMOTE RESISTANCE; REMOVE STANDING TREES WITH SUNKEN CANKERS OR DEAD PATCHES TO REDUCE SPROUTING OF DISEASED INDIVIDUALS. RETAIN SOME LARGE BEECH TREES THAT HAVE POTENTIAL FOR GOOD MAST PRODUCTION, REGARDLESS OF DISEASE CONDITION.
- LAY OUT SKID TRAILS AND ROAD TO AVOID VIGOROUS PATCHES OF UNDERSTORY SHRUBS.
- WHEN POSSIBLE, SAVE ALL HARDWOOD MAST TREES THAT OCCUR IN CONIFER PLANTATIONS.

6.3.6 Wildlife Trees

Wildlife trees are often divided into two categories: snags and den trees. Snags are standing dead or partially dead trees at least 6" dbh and 20 ' in height. Den trees are live trees possessing a cavity large enough to serve as shelter for birds and mammals or a site to give birth and raise young. In general, den trees must be 15" or greater in dbh and have a minimum cavity opening of 4" in diameter (Blodgett 1985). Over 50 species of northeastern birds and mammals utilize snag and den trees during part of their lives (Blodgett 1985). Some uses of snags and den trees include cavity nest sites, nesting platforms, food cache, dwellings or dens, nesting under bark, overwintering sites, hunting and hawking perches, sources of feeding substrate, and roosting.

Forestry operations most likely have the greatest potential impact on the number, type, and location of snag and den trees at the Ware River. Thinnings, salvage, firewood cutting, and windthrow will result in wildlife tree loss. However, the Division's use of uneven-aged management is conducive to snag management. Single-tree or group selection harvest practices allow the maintenance of an optimal number of snags and dens across the watershed (Table 12).

TABLE 12: OPTIMUM NUMBER OF SNAGS AND DEN TREES PER 100 ACRES BY HABITAT TYPE

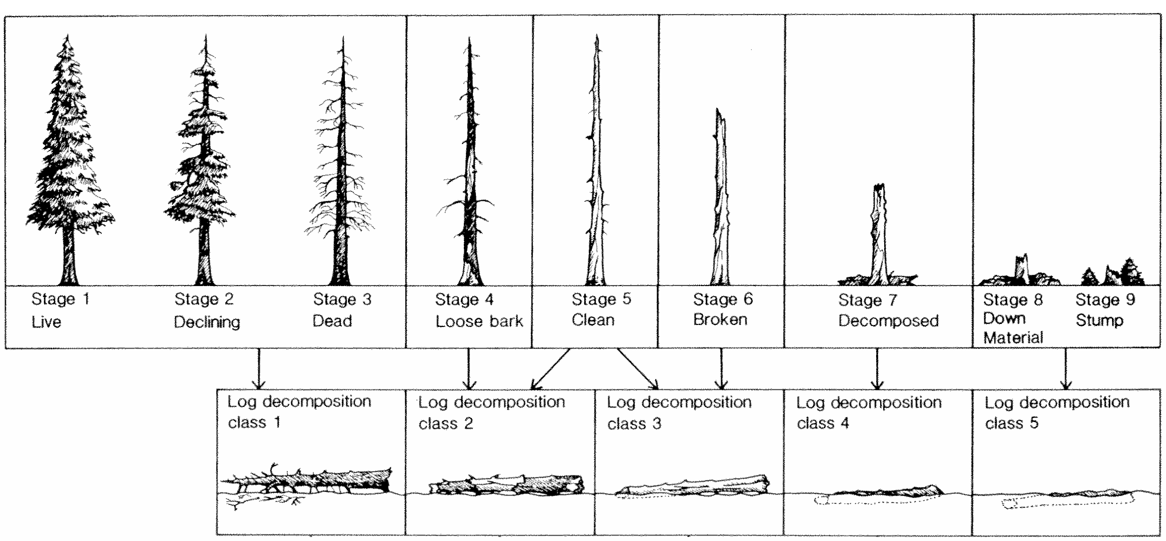
Tree Size	Forest Interior		Semi-open/open	Wooded Watercourse
Tree dbh (inches)	Dens	Snags	Dens[1]	Dens[1]
> 19	100	0	300	200
10-19	400	400	400	1400
< 10	200	200	300	900

[1] Animals here need den trees because creating snags by deadening trees is not recommended in these land-use patterns.
Source: Payne and Bryant, 1994

6.3.6.1 Snags

As a tree dies, it progresses through several stages of decay (Figure 11) and is used by different wildlife at each stage. Newly exposed bare branches provide excellent perches for woodland hawks (Cooper's, sharp-shinned), as well as flycatchers and phoebes. During the loose bark stage, brown creepers and bats may nest or roost under the bark.

FIGURE 11: DECOMPOSITION STAGES OF SNAGS AND DOWNED WOODY LOGS (HUNTER, 1990)



As a tree deteriorates, primary excavators (woodpeckers) begin to create cavities. Almost all northeastern woodpeckers excavate nest cavities in live or dead trees. Secondary nesters then use these cavities. Once trees have decayed to a point where there are no longer branches, it is classified as a snag (< 20 feet tall is a stub). Many insectivorous birds will use the snag for foraging. Finally the snag will either topple to the ground or wear to a stump. The fallen log provides habitat for carpenter ants and other insects. In addition, amphibians and reptiles will live in and under the rotting wood. Small mammals also utilize the downed logs.

In addition to the stages of decay, other variables determine a particular snag's value to specific wildlife species. Characteristics such as tree size, location, species, and how it was killed are important determinants of wildlife use (DeGraaf and Shigo 1985). In general, when managing for cavity trees, "bigger is better." While small birds are able to find nest sites in both small and large trees, large birds need large diameter trees in which to excavate nesting cavities. In addition, large snags usually stand longer than smaller ones. Emphasis is often placed on managing for viable woodpecker populations because their success will provide enough nesting sites for secondary cavity nesters (Table 13).

TABLE 13: NUMBER OF CAVITY TREES NEEDED TO SUSTAIN WOODPECKERS

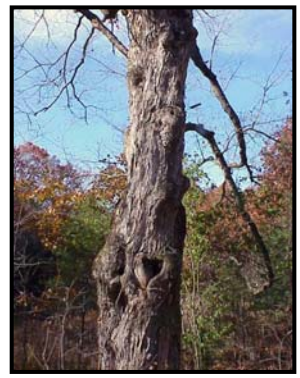
Species	Territory Size (Acres)	Avg. nest tree[1]		(A) Cavity trees used, minimum (N)	(B) Pairs/100 acres, maximum (N)	(C) Cavity trees needed/100 acres[2] (AxB) (N)
		DBH (in.)	Height (ft.)			
Red-Headed Woodpecker	10	20	40	2	10	20
Red-bellied Woodpecker	15	18	40	4	6.3	25
Yellow-bellied Sapsucker	10	12	30	1	10	10
Downy Woodpecker	10	8	20	4	10	40
Hairy Woodpecker	20	12	30	4	5	20
Three-toed Woodpecker	75	14	30	4	1.3	5
Black-backed Woodpecker	75	15	30	4	1.3	5
Northern Flicker	40	15	30	2	2.5	5
Pileated Woodpecker	175	22	60	4	0.6	2.4

Source: DeGraaf and Shigo, 1985.
[1] Larger trees may be substituted for smaller trees.
[2] Number of cavity trees needed to sustain population at hypothetical maximum level.

Snag Management Objectives: Forestry operations will continue to provide a supply of good to excellent quality snag trees, distributed over time and space in order to maintain self-sustaining populations of all cavity-dependent wildlife. In areas where good snag trees are lacking, poorer quality trees will be retained until better trees develop.

Recommended Practices for Snags:

- WHEN POSSIBLE, LEAVE ALL SNAGS WITHIN 100 FEET OF WETLANDS AND RIPARIAN AREAS.
- MAINTAIN A MINIMUM OF 6 SNAG TREES PER ACRE; AT LEAST 4 SHOULD BE > 24" DBH.
- AVOID DISTURBING SNAGS FROM APRIL TO JULY TO AVOID DISTURBING NESTING BIRDS AND DENNING MAMMALS.
- IF SNAGS MUST BE FELLED DURING MANAGEMENT OPERATIONS, THEN LEAVE THEM IN PLACE INSTEAD OF REMOVING THEM.
- WHEN POSSIBLE, IDENTIFY CURRENT OR POTENTIAL SNAGS THROUGH EXTERIOR SIGNS SUCH AS FUNGAL CONKS, BUTT ROT, BURLS, CRACKS, WOUNDS/SCARS FROM LIGHTENING, FIRE OR MECHANICAL DAMAGE, WOODPECKER HOLES OR CAVITIES, OR DEAD OR BROKEN LIMBS OR TOPS SO THAT THEY CAN BE RETAINED.



6.3.6.2 Den Trees

Den trees are living, hollow trees used by a variety of mammals including mice, raccoons, squirrels, and bears. In general, there are usually fewer den trees available in an area than could be used by wildlife because large (>15" dbh) rough or rotten trees are relatively rare.

Unlike cavity trees, which have central columns of decay, den trees are hollow or have large hollow limbs, but are still alive and vigorous. Den trees usually have easily visible openings in the sound wood. Some heavily-used den trees, such as those used by raccoons, are hardwoods with the top snapped off. Den trees usually have low commercial value, but their value to wildlife is extremely high and long lasting. It may take 100 years to develop large den trees, and once developed some trees (oaks, sugar maple) can live for several hundred years (DeGraaf and Shigo 1985). Once den trees die and fall to the ground, the remnant hollow log may last another 25 years, providing breeding habitat for a number of species including redback salamanders and ringneck snakes.

Den Tree Management Objectives: The Division will retain good to excellent quality den trees, distributed over time and space in order to maintain self-sustaining populations of all cavity dependent wildlife. In areas where good den trees are lacking, poorer quality trees will be retained until better trees develop.

Recommended Practices for Den Trees:

- RETAIN LIVE TREES WITH EXISTING CAVITIES AND LARGE UNMARKETABLE TREES.
- RETAIN 2 OR MORE TREES > 29" DBH PER 100 ACRES.
- LEAVE AT LEAST 1 TREE 15-29" DBH PER ACRE.
- LEAVE AT LEAST 1 LONG-LIVED TREE PER ACRE THAT SHOWS POTENTIAL FOR DEVELOPING INTO A DEN TREE (BROKEN TOP, LARGE BROKEN LIMBS, FIRE SCARS).
- LEAVE ALL DEN TREES WITHIN 100 FEET OF A WETLAND AND WITHIN RIPARIAN AREAS.

6.3.7 Downed Woody Material

Downed woody material refers to slash, logs, large and small limbs, stumps, and upturned tree roots that accumulate on the ground either naturally or through forestry operations. Downed woody debris provides food, cover, and nursery habitat for a range of flora, fauna, and fungi. Downed woody material provides critical wildlife habitat and is used for nesting, shelter, drumming, sunning, as a source of and place to store food, and as natural bridges. The specific value of downed woody debris depends on the physical distribution, amount, size, degree of decay, and orientation of debris relative to slope and exposure (Flatebo et al., 1999). Decaying logs also serve as nurse-trees for seedlings and colonization sites for fungi. Too much or too little downed woody material can be detrimental to wildlife. In general, it is best to retain or produce downed woody material that is distributed similarly to what would occur naturally.

Logs are generally considered to be the most valuable downed woody material because of their slow decay and longer persistence. Long logs >16" dbh are especially important wildlife habitat features. As logs age and decay, their role as wildlife habitat shifts. Logs supported by branches provide shelter, feeding, and display sites for a variety of birds and mammals. As the log settles to the ground and continues to decompose it may be used by small mammals, snakes, toads, and salamanders for shelter, food, and travel. Large logs with hollow portions may be used as den sites by larger mammals.

Downed Woody Material Management Objective: The Division will continue to maintain a range of sizes and types of downed woody material and retain or provide downed woody material in sites where it is lacking.

Recommended Practices for Downed Woody Material:

- If snags must be felled during management operations, leave them in place.
- Avoid damaging existing downed woody material during harvesting, particularily large (>16 inch dbh) hollow logs and stumps.
- When possible, leave at least 4 logs of decay class 1 and 2 per acre (Figure 11); at least 2 of these logs should be >12 inch dbh and >6 feet long. Hollow butt sections of felled trees can be used.
- Retain as many logs as possible of classes 3, 4, and 5 (Figure 11)
- On slopes, orient logs along contours and place against stumps when possible.
- In clearcuts, leave slash on at least 10% of the site scattered in piles or rows.
- Do not add debris to streams and avoid disturbing woody material already in streams.

6.3.8 Woodland Raptor Nests

Hawks, owls, falcons, and vultures are known as raptors. There are 19 species of raptors that breed in New England, 16 of which are known or potential breeders on the Ware River watershed (Table 14).

TABLE 14: ACTUAL AND POTENTIAL BREEDING RAPTORS ON WARE RIVER WATERSHED

Species	Breeding Status	Nest Site Selection
Turkey Vulture	Breeder	Rocky outcrops, ledges, cavities
Osprey	Potential Breeder[1]	Stick nests in trees, snags, poles
Bald Eagle[2]	Potential Breeder	Stick nests in living trees
Northern Harrier[2]	Potential Breeder	On ground, over water
Sharp-shinned Hawk[2]	Potential Breeder	Stick nest on tree limb-usually conifers
Cooper's Hawk[1]	Potential Breeder	Stick nest (may use old crow nest) on horizontal branch in hardwood or conifer
Northern Goshawk	Breeder	Stick nest (used or new) in hardwood
Red-shouldered Hawk	Breeder	Stick nest (new) in tall tree
Broad-winged Hawk	Breeder	Stick nest in tall tree
Red-tailed Hawk	Breeder	Stick nest in oak/white pine
American Kestrel	Breeder	Cavity, nest box
Barn Owl[2]	Non-Breeder	Cavities, buildings, artificial
Screech Owl	Breeder	Cavities and woodpecker holes (Pileated/Flicker)
Great-horned Owl	Breeder	Cavities, old crow, hawk, or heron nests
Barred Owl	Breeder	Large natural cavities or old bird nests
Long-eared Owl[2]	Potential Breeder	Old crow/hawk nest or natural cavity
Saw-whet Owl	Breeder	Natural cavity or woodpecker hole
Short-eared Owl	Non-Breeder	Open fields, heath on Cape/Islands
Peregrine Falcon	Non-Breeder	Cliffs, tall buildings, urban areas

Source: adapted from DeGraaf and Rudis 1986
[1]Potential breeders are raptors not known to be currently breeding within the Ware River watershed, but given the bird's range and habitat requirements they could breed there presently or in the future.
[2]Listed with the Massachusetts Natural Heritage and Endangered Species Program as an endangered, threatened or special concern species.

Most raptors are predators and feed upon birds, mammals, fish, amphibians, insects, and snakes. While most raptors will eat a variety of animals, some species like the osprey have much narrower food requirements. Compared to other birds, raptors require relatively large home ranges (60 - >900 acres) in order to meet their food and nesting requirements. Raptor nests are widely dispersed across the landscape in a variety of habitats and forest conditions.

Some raptors will build a new nest each year within their territory, while other raptors will use the same nest for a number of years or claim the nest built by another species. Raptor nest trees must be large and strong enough to support nests ranging from 18 inches in diameter (broad-winged hawk) to over 3 feet (bald eagle, northern goshawk) (Flatebo et al., 1999). Large-diameter broken stubs, closely spaced branches halfway up large white pines, and 3-pronged main forks of mature hardwoods are most frequently used by stick nest building raptors. Preserving existing nests and potentially good future nest trees will help maintain raptor populations in an area over a long period.

Many raptors nest early in the year. By February-March, most great-horned owls and some red-tailed hawks and barred owls are incubating eggs. Most other raptors will be incubating by May. Nesting raptors can be vulnerable to human disturbance. There is a wide range of tolerance depending on the species. Some intolerant species (such as bald eagles and goshawks) may abandon the nest during the early weeks of incubation. Repeated flushing of the incubating bird from the nest may also subject the eggs to fatal chilling or the young to predation.

Identifying active nests is critical to ensuring their protection and establishing a buffer zone to minimize disturbance. The easiest, and unfortunately most infrequent, way to detect active nests is to see birds in or around the nest. However, active nests can be identified when no birds are visible by looking for the following indicators:

- Prior to egg-laying, some raptors decorate the nest with fresh branches, usually from a conifer.
- After hatching, whitewash (excrement), regurgitated pellets, and prey remains may be found on the ground near the nest tree.
- Raptor nests can be distinguished from squirrel nests by their shape (squirrel nests are saucer-shaped) and lack of leaves (squirrel nests are made mostly of leaves).

Woodland Raptor Nests Management Objective: The Division will maintain suitable nesting sites for woodland raptors across the landscape over time and will avoid disturbing nesting pairs of raptors.

Recommended Practices for Woodland Raptor Nests:

- CONTACT DIVISION'S WILDLIFE BIOLOGIST WHEN PLANNING FOREST MANAGEMENT ACTIVITIES IN THE VICINITY OF A BALD EAGLE NEST.
- INSPECT MATURE WHITE PINE AND HARDWOOD TREES FOR LARGE STICK NESTS WHEN CRUISING TIMBER STANDS. WHEN POSSIBLE, DO NOT CUT TREES CONTAINING LARGE STICK NESTS AND HARDWOODS WITH 3-PRONGED FORKS.
- MAINTAIN AN UNCUT BUFFER OF AT LEAST 66 FEET AROUND ACTIVE RAPTOR NESTS AND RETAIN 65-85 PERCENT CANOPY CLOSURE WITHIN 165 FEET OF LARGE STICK NESTS AND HARDWOODS WITH 3-PRONGED FORKS.
- IF AN ACTIVE RAPTOR NEST IS LOCATED BEFORE OR DURING A SCHEDULED HARVEST OPERATION, MAINTAIN AN UNCUT BUFFER OF AT LEAST 66 FEET AROUND THE NEST TREE, AND DO NOT HARVEST WITHIN 330 FEET OF THE NEST DURING APRIL-JUNE.
- IF AN ACTIVE RAPTOR NEST CAN BE POSITIVELY IDENTIFIED AS BELONGING TO A COMMON OR TOLERANT SPECIES (I.E. , RED-TAILED OR BROAD-WINGED HAWK), THEN HARVESTING SCHEDULES AND BUFFER ZONES MAY BE RELAXED.
- RETAIN OCCASIONAL SUPER CANOPY PINES NEAR THE RESERVOIR SHORELINE AS POTENTIAL FUTURE NEST TREES FOR BALD EAGLES.
- FOLLOW APPROPRIATE SNAG TREE MANAGEMENT GUIDELINES.

6.4 Assessment of Impacts of Planned Watershed Management Activities on Wildlife

The management activities described in this plan will have various impacts on the wildlife community at the Ware River. Most impacts will be a result of habitat changes or modifications. The forest management approach described in this plan has landscape level effects, although individual changes at any given time will be localized and relatively small.

The amount and types of habitat at the Ware River have been dynamic since early colonial times. Once covered by primeval forest, a majority of the land in the Ware River watershed was cleared for agriculture during the 18th and 19th centuries. This trend persisted until about 1840 when 75 percent of the arable land was in pasture or farm crops (DeGraaf et al., 1992). The next 100 years was another period of dramatic change as most of the farmland was abandoned and new forest invaded the former fields.

Dramatic changes in the wildlife community accompanied these broad landscape changes. Some species thrived and expanded their range, while other were temporarily extirpated or became extinct. When agriculture dominated the landscape, it is likely that numbers of black bears, wild turkeys, forest songbirds, and other species adapted to forested conditions were greatly reduced throughout much of their former range. Bluebirds were abundant during the agricultural period, but are now relatively uncommon breeders. Other open habitat species (bobolinks, vesper sparrows, and golden-winged warblers) that were also common during the heavy agriculture periods have also declined as their available habitat reverted to forest cover.

Most of the undeveloped land in the Ware River watershed today is forested. While the Division's management activities will alter habitat and wildlife species composition, probably the most significant impacts to the wildlife community have been these large regional changes in land use. In addition, continued human population expansion in central Massachusetts has meant the loss of more and more open space as it is converted to residential housing. Further, large-scale disturbances to the landscape such as the 1938 hurricane and periodic fires have shaped the existing wildlife community.

For the most part, the Division's forests are multi-aged, multi-species. Future management will be focused on encouraging regeneration and improving the health and vigor of the forest. While the management techniques used to reach these goals will not be as dramatic as previous landscape-level events, it is important to understand how this management will affect the habitat and wildlife communities on the watershed.

6.4.1 Three-Strategy Forest Management: Impacts to Wildlife

The Division's primary long-term forest management goal is to establish and/or maintain a forest cover of diverse native tree species of many different age classes on a majority of its land holdings in order to protect water quality. This will be accomplished through uneven-aged forest management, even-aged forest management, and the establishment of forest reserves. Harvest will be through selection of individual trees or small groups up to 2 acres in size. In limited areas, larger openings up to 10 acres will be created. As a result, the wildlife community on Division land will be dominated by species adapted to these forest conditions. Uneven-aged management is the best technique for preserving individual trees of high wildlife value such as dens, nests, roost, and mast producers (Payne and Bryant, 1994). In addition, uneven-aged management maximizes vertical diversity. Even-aged management can be beneficial to a variety of wildlife species, and forest reserves can also play an important role in maintaining biodiversity.

Meeting this primary goal will mean wildlife communities on Division land will be dominated by species adapted to a variety of forested conditions. Those species requiring early-successional non-forested habitat will be less common and restricted to those limited areas where this type of habitat exists. Open, non-forested habitat will be maintained on a small percentage of the Division's land, primarily associated with fields, open land associated with developed areas, beaver impoundments, and openings deliberately created for biodiversity. In general, wildlife species adapted to forest cover should benefit the most from the Division's land management plan for its Ware River watershed properties.

6.4.1.1 Strategy One Areas

Strategy One areas will not be actively managed and include wetlands and hard-to-access parcels. These areas total approximately 5,700 acres and are located across the watershed. Because these areas are essentially unmanaged, they can be classified as forest reserves. Forest reserves can serve a variety of useful functions, including having unique aesthetic and recreational value. In addition, reserves can function as reference sites in which to measure the effects of forest management on various wildlife communities. Finally, forest reserves are critical when addressing biodiversity. Setting aside areas where natural processes can proceed without human interference is necessary in order to fully address biodiversity because some birds, invertebrates and mammals depend on old-growth forests.

Locations of forest reserves created on the Ware River are largely related to hydrologic and/or topographic features of the landscape, and thus are not necessarily representative of the all habitat types present on the watershed. Unmanaged areas at the Ware River are confined to wetlands and areas where active forest management cannot occur. Therefore, protection is biased towards these habitats and the species that occur in them. In order to assure that all potential aspects of biodiversity are addressed, forest reserves need to be representative of the ecosystems present.

Even though Strategy One areas were selected using specific criteria, they still represent areas of biological importance. Many rare and endangered species in Massachusetts rely on wetlands during their life cycle. Setting aside wetland habitat into reserves should benefit these species. In addition, creating areas of old growth forest should benefit a wide variety of wildlife species.

6.4.1.2 Strategy Two Areas

In Strategy Two areas, uneven-aged silvicultural techniques will be used to create gaps and openings up to ¼ acre in size. Approximately 3,700 acres will be managed under Strategy Two, and these areas include buffer strips along riparian areas and roadsides. Management techniques used in Strategy Two areas include single-tree and small group selection, as well as an extended version of the shelterwood method of regeneration. The primary silvicultural method proposed during this 10-year plan within Strategy Two areas will be single tree selection creating openings up to ¼ acre in size. As mentioned above, single tree selection essentially maintains an intact forest canopy and is well suited to regenerating shade-tolerant tree species. Those wildlife species requiring continuous forest canopy and large tracts of unbroken forest habitat are favored by single tree selection because the integrity of the habitat is not altered. Many Neotropical migratory forest songbirds (e.g., forest warblers, wood thrush, and ovenbird) are edge sensitive species that require unbroken tracts of forest to successfully breed. When single trees are removed from the forest, no edge or transition habitat is created and the forest interior is maintained. While this will benefit these edge sensitive species, those species that rely on early-successional habitats (e.g., Eastern towhee, chestnut-sided warbler) will be limited to areas where these habitats exist.

6.4.1.3 Strategy Three Areas

In Strategy Three areas, a range of forest management techniques will be employed from single-tree selection to small group openings (up to 2 acres) to even-aged forest management. Even-aged management will be used to create forest openings 5-10 acres in size depending on whether reserves are left. Approximately 13,500 acres fall under Strategy Three areas and these include plantations, poor quality stands or poorly-sited stands, as well as more typical "site-suited" forest stands.

6.4.1.3.1 Group Selection

Much attention has been focused recently on the potential problems of forest fragmentation in the northeast. Most of this effort has centered on Neotropical migratory birds and the continued decline of some species. It has been shown that area-sensitive songbirds do not reproduce well along edge habitats (Sullivan and Brittingham, 1994). In most cases, when trying to conserve edge-sensitive species, it is recommended that extensive areas of contiguous forest are maintained and the amount of edge habitat minimized. Although the Ware River watershed is located within a fragmented landscape, the Division owns large areas of contiguous undeveloped habitat. It is hard to speculate how much impact Division forest management activities that remove 2 or more acres of trees will have on edge-sensitive species. Alterations to Division forested land is not analogous to what would occur if the same land were developed for residential housing or agriculture. However, since the Division proposes to use group selection (up to 2 acres) and/or even-aged management to treat a majority of their stands, it is prudent to consider the impact of these practices on wildlife communities.

The most influential factor associated with this type of silviculture would be the introduction of edge effects. Many studies have documented the reduced nesting success of songbirds near forest edges when compared to the interior (Wilcove, 1988). This reduced success is a result of nest predators (e.g., blue jays, chipmunks, raccoons, crows) and/or nest parasites (e.g., brown-headed cowbird). In addition, rates of cowbird parasitism increase near openings within large forest tracts (Wilcove, 1988). Initially it might appear that edge effects would be limited to isolated woodlots surrounded by houses or barren land. Division land within the Ware River watershed is almost exclusively forested, and most of the forest is more than 60 years old. Unfortunately, edge effects are applicable to forest ecosystems because even small openings within forests create edges.

Although most changes in vegetation caused by group selection extend only 30-100 feet into the forest, increases in nest predation and parasitism may extend as far as 1,000-2,000 feet into the forest. Therefore a small number of openings in the forest could impact a large area. Careful placement and concentration of openings would help minimize edge effects by leaving large areas of mature forest intact.

Impacts of fragmentation on mammals are less well known. It is likely that species most sensitive to forest fragmentation were extirpated long before they could be studied. Mountain lions, wolves, elk, and woodland bison have been gone from the watershed for decades. As a result, those mammals left within the watershed are the ones adapted to surviving in fragmented, human-altered landscapes. It is likely that the main limiting factor on large mammal populations is human disturbance and not fragmentation.

Openings within forests do benefit some wildlife species, which depend on herbaceous and early-successional openings. Wild turkey, ruffed grouse, Eastern towhee, red-shouldered hawk, and white-tailed deer will benefit from the proposed openings that will be created. Forest openings will allow for denser ground cover, increased light, and a more open canopy.

6.4.1.3.2 Non-harvest Cutting on Sensitive Sites

On some sensitive areas where tree cutting still needs to occur (e.g., inaccessible pine plantations, shorelines, hurricane exposed areas), the Division proposes to cut trees but not remove them. This would enhance forest regeneration without negatively impacting the sensitive sites. This type of management may be used on a limited portion of Division land. Because this is being proposed on such a limited area, it will have little impact on wildlife species at the landscape level.

The Division may also conduct non-removal harvest of trees along riparian wetlands to increase light and stimulate regeneration. Cut trees will be left in place along the riparian area. This will add coarse woody debris, providing additional cover and nutrients for forest floor wildlife. The additional light will allow for a greater diversity of understory trees and ground cover. This will benefit wildlife species that utilize a dense understory layer of vegetation.

This management practice could have potential negative impacts on the wildlife community depending on where the harvesting occurred and how many overstory trees were removed. Removing a large number of deciduous trees along the riparian zone could negatively impact species using wooded stream courses as travel corridors. However, if single trees or small groups were removed, these impacts would likely be minimal. On some streams there is almost continuous conifer (hemlock) cover which characteristically has little understory regeneration. This habitat type is uncommon on the watershed and provides unique habitat for a variety of wildlife. Removing trees in these areas could alter the microclimate of the area and have potentially negative effects on the wildlife and stream community. The hemlock woolly adelgid will likely bring about some of these effects with or without intervention.

When harvesting trees along the riparian area it is important to try tp save cavity or potential cavity trees. Cavity trees along riparian wetlands are extremely valuable to a range of wildlife species.

A final consideration regarding this management technique would be to recognize that stimulating regeneration and new growth along riparian wetlands will be beneficial to beaver populations. Availability of a winter food supply is an important factor affecting beaver distribution in areas where stable water levels are possible.

6.4.1.3.3 Removal of Plantations

The full overstory removal of plantations results in dramatic and immediate changes with regards to wildlife habitat and species. Full overstory removal is essentially even-aged management and results in both positive and negative impacts to wildlife. In general, removing the overstory will provide early-successional habitat that is utilized by a variety of species. Early-successional species will particularly benefit from this management because the larger stand size will attract and sustain larger populations of those species. Those species requiring continuous forest canopy will be negatively impacted by these treatments. In addition, species utilizing conifer-dominated habitat (e.g., red squirrels, some neotropical migrants, nesting raptors) may be displaced.

6.4.1.3.4 Effects of Even-Aged Management on Wildlife

Even-aged forest management is the best technique for producing and sustaining large amounts of early-successional forested habitat. Early-successional forested habitat provides a unique set of characteristics that are beneficial to a variety of wildlife species. Some of these species depend exclusively on this type of habitat (for a complete description, see section 7.5, Maintenance of Early-successional Habitat for Landscape Diversity). Further, no breeding birds are restricted to uneven-aged forest habitats, while many species are restricted to even-aged habitats, particularly regenerating or sapling-sized stands (Thompson and DeGraaf, 2001).

The Division proposes regenerating approximately 135 acres per year in Strategy 3 areas. The resultant habitat should greatly benefit those species requiring early-successional forested habitat. For example, New England cottontail rabbits, prairie warblers, woodcock, and bobwhite quail are dependent on this type of habitat and should benefit from its creation. In order to maximize the potential benefit of creating early-successional habitat, openings could be clustered to simulate a much larger opening.

6.4.2 Considerations during Timber Marking, Harvesting, and Other Land Management Activities

While careful planning and preparation can mitigate many of the potentially negative impacts on wildlife resources, some specific impacts or events cannot be discovered until operations begin in the field. Locations of active raptor nests, quality den and snag trees, and seeps may not be discovered until foresters begin marking individual trees in a lot. It is during these detailed lot inspections that some of the specific wildlife habitat management recommendations can be implemented. In addition, broader considerations such as timing of operations, harvesting techniques, record keeping, and other miscellaneous considerations should be addressed.

6.4.2.1 Timing of Operations

The timing of land management activities can have a dramatic impact on wildlife species. Some species (e.g., bald eagle, great-blue heron, and coyote) are extremely sensitive to human disturbance and may abandon or forgo breeding when repeatedly disturbed. Fortunately, nesting or denning areas of some sensitive species are already known, or can be easily identified. Great-blue herons nest in visible colonies, usually in dead snags over water. In addition, bald eagles build large stick nests that are easily seen and may be used for many years. However, for most other species, their nest, burrow, or den is well hidden and might not be discovered until an operation had already begun. Luckily, most wildlife species nest or den during the spring and early summer when land management activities are restricted.

Division personnel will notify the wildlife biologist when land management activities have clearly disrupted a rare or uncommon species' breeding activity. The Division wildlife biologist will assess the nature of the nesting/denning activities and determine what species is involved, what stage of breeding is occurring (courtship, incubation, brooding, etc.) and how the animals responded to the initial disturbance. The Division will determine what options will be used to mitigate and avoid further disturbance during the remainder of the breeding season.

Land management activities conducted at other times of the year may unknowingly impact wildlife species, and efforts will be made to reduce these conflicts. Maintenance (mowing, burning, etc.) of fields and open areas should only be done in early spring (March/April) or after August 1 to avoid disrupting nesting birds and mammals. No activity should occur in or near seeps during winter. If possible, winter activity in and around identified wildlife wintering areas should follow the guidelines in section 6.3.4.

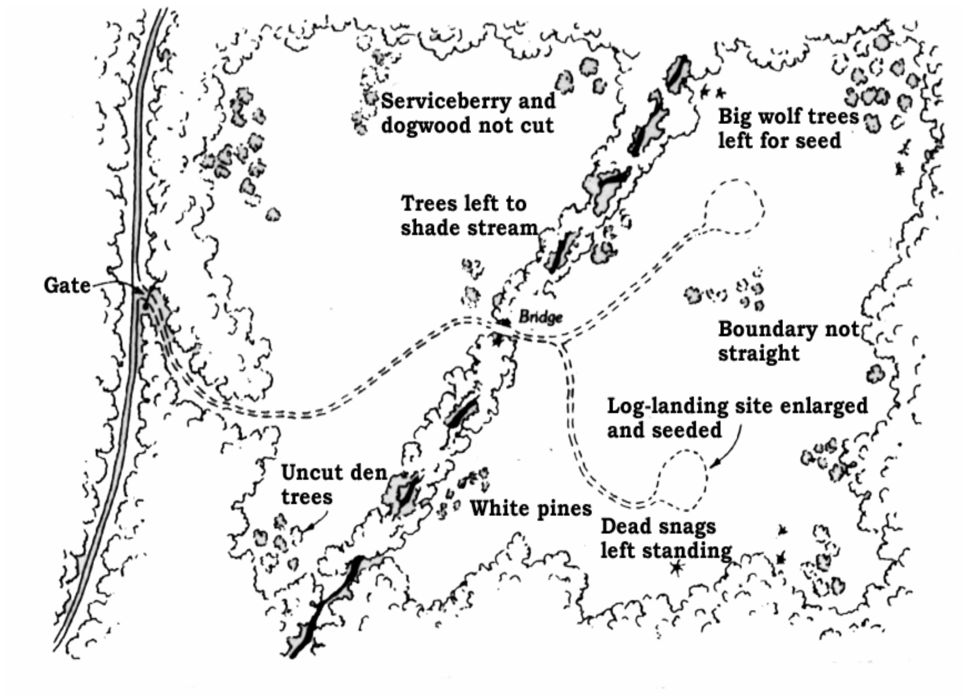
In some cases, activity during certain times of the year is preferred. Working around vernal pools is often best during winter when frozen/dry conditions minimize rutting and disruption of the forest floor. Further, logging during the fall and winter usually has minimal impact on most wildlife habitats and may actually benefit some animals by providing additional browse and cover.

Land management activities conducted at any time of the year have the potential to disrupt some wildlife species. This disruption is usually small in scale and centered in the vicinity of the logging operation and the benefits derived from actively managing the watershed lands may outweigh the localized disruption. Nonetheless, the Division will continue to gather data on critical and sensitive wildlife and their habitats on the watershed, and will adjust the timing or location of logging operations as necessary in order to avoid impacts on special concern species.

6.4.2.2 Group Selection Considerations

Certain techniques and considerations can be used to enhance the area for wildlife uses when forestry operations use group selections to remove trees in openings 1 acre or greater in size,. With proper planning, harvesting operations can be conducted while still maintaining snags, den trees, and mast producing trees within the opening (Fig.12). In addition, creating an irregular, feathered border will help reduce nest predation and parasitism.

FIGURE 12: FOREST OPENING PLACED WITH WILDLIFE CONSIDERATIONS



6.4.2.3 Logging and skid roads

Access roads are used by the Division to collect water samples, remove wood, control fires, maintain watershed structures, and aid in navigation. Most Division roads within the watershed are narrow, grassy woods trails often referred to as logging roads. While roads are necessary to the Division, they can also act as barriers to animal movements and fragment the forest.

The effect of forest roads on wildlife and biodiversity depends on the size, type and location of the road. The frequency with which a road is used and its proximity to sensitive resources also determine its impacts. Roads effectively create an edge habitat that benefits some species, but has negative effects on species sensitive to disturbance or predators. Roads are often used by some wildlife species as travel lanes, but they may impede the movements of other species that require continuous vegetative cover. Roads may also fragment the forest and isolate individuals or populations.

Constructing and maintaining forest roads on Division property constitutes a relatively permanent change in the habitat structure of the area. There is little concern about direct mortality on wildlife populations because traffic on Division roads, particularly at night, is minimal. A strip of dirt or gravel under an open canopy can serve as a physical or psychological barrier to animal movements, however, including small mammals, amphibians, and invertebrates (deMaynadier and Hunter, 2000).

When logging roads, skid trails, and landings are being planned, certain design features can be incorporated to minimize wildlife impacts. Logging roads/skid trails should avoid vigorous patches of shrubs. New logging roads should be minimized and existing roads should be upgraded instead if possible. Roads should be as narrow as possible, ideally one-lane with occasional turnouts. Circular routes should be avoided; a cul-de-sac design is better. When possible, abandoned logging roads, skid trails, and landing sites should be seeded with a grass-legume mixture. Road intersections should be angled to limit line of sight.

6.4.2.4 Record Keeping

Division foresters, rangers, and other natural resource staff spend a large amount of time walking, observing, and assessing lands within the Ware River watershed. It is likely that they may observe significant wildlife or important wildlife habitats. Because of the size of the watershed, these anecdotal observations are an important source of biological information, and may be valuable in determining how to avoid or mitigate potential wildlife impacts of future land management activities. These observations must be reported to the Division wildlife biologists so that records may be routinely maintained and updated.

6.4.2.5 Miscellaneous Considerations

The Division's silvicultural practices often include cutting trees with weak crown forms that are more susceptible to damage. Some of these trees have wildlife value, and Division foresters will continue to leave some of these trees uncut. For example, trees growing on an angle following partial windthrow serve as travel routes for arboreal mammals from the ground to the forest canopy. In addition, older trees with large stocky limbs often have protected crotches that are used by nesting birds and mammals. These trees also typically have a high potential for cavity formation. While it is not necessary to maintain all examples of these trees, it is important to retain some during harvesting operations.

Particular combinations of trees species are also valuable to wildlife. For example, mature oak trees within hemlock or other conifer stands provide food resources within wildlife wintering areas. Small pockets of hemlock within hardwood stands can provide important wildlife cover. Both of these habitat conditions should receive special treatment when feasible.

6.5 Wildlife Populations Requiring Monitoring and/or Impact Control

The Division's primary responsibility is to the long-term protection of the drinking water supply provided from its watersheds. Most wildlife populations on these watersheds are controlled by a combination of natural predation and competition, and their potential impacts on water resources and other Division interests are therefore limited. However, populations of some species are primarily controlled through human intervention (hunting, trapping) and impacts on water quality or other resources are possible if this population control is reduced (Table 15). In general, it is the Division's policy not to interfere with natural wildlife activity. However, when wildlife populations or activities significantly impact either water quality or the integrity of watershed structures or resources, then the Division must take an active role in mitigating those damages. The species of concern and their associated risks are discussed below.

TABLE 15: POTENTIAL WILDLIFE IMPACTS OF SPECIAL CONCERN.

Species	Impact on Division Resources, Structures, and/or Water Quality
Beaver	Can cause damage to watershed structures and property; can negatively impact water quality depending on their location and site conditions
White-tailed deer	Can alter diversity and abundance of tree regeneration
Moose	Can alter diversity and abundance of tree regeneration

6.5.1 Beaver


Beaver lodge

6.5.1.1 General Comments

Beaver can dramatically alter their surrounding habitat, which in turn can affect other wildlife species and humans. Beaver have been linked to water-borne pathogens and are potential carriers of both *Giardia spp.* and *Cryptosporidium spp* (MDC, 1999). In addition, beaver can cause localized damage to roads, culverts, and trees, although the habitat they create is seen as beneficial to a variety of wildlife species. Whether any given beaver colony is seen overall as beneficial or detrimental depends on various factors including location in the watershed and the structures or the resources affected. Division policy regarding beaver takes into account the variety of situations that may arise and applies solutions as needed to offer the best long-term remediation. Because beaver issues can become quite controversial, it is important to discuss and highlight the range of potential beaver impacts on a variety of resources.

6.5.1.2 Beaver Induced Alterations of Riparian Systems

Beaver are one of the few wildlife species that have the ability to dramatically alter the surrounding habitat to their benefit. These habitat alterations can have potentially substantial impacts on the ecosystem. Changes in vegetation, biotic and abiotic features of the wetland and downstream water bodies, and impacts to other organisms may result. Riparian areas, particularly along second- to fourth-order streams and adjacent low-lying areas are often colonized by beaver (Hammerson 1994). The presence or absence of beaver in an area or region can have a dramatic impact on the predominant vegetation. For example, in West Virginia, the widespread swamp forests common in the early 1900s were most likely the result of the eradication of beaver from the state by the early 1800s (Land and Weider, 1984, *in* Hammerson 1994). Except at beaver-occupied sites, Division-owned riparian areas are primarily forested with a variety of tree species. It is interesting to note that these forested wetlands in Massachusetts may be an artifact of the beaver's eradication from the state by the late 1700s until their eventual return in 1928 (1950s at Quabbin). The absence of beaver allowed these riparian areas to grow maturing forests. Recent changes to the riparian landscape caused by expanding beaver populations may appear even more dramatic as a result.

The Division's primary interest is to preserve and protect water quality within the water supply reservoirs, and riparian areas are a critical component of that protection. As a result, it is helpful to summarize the impacts of beaver on the biotic and abiotic components of riparian ecosystems in order to address potential negative impacts from their occupation of riparian areas.

One of the most important factors related to changes in the environment is the structural integrity of beaver dams. Many of the effects associated with beaver occupation of riparian zones are contingent on the longevity and stability of the dam itself. Dams that continually wash out may cause water quality problems associated with flooding and the sudden release of sediment and accumulated nutrients. It is usually dams on larger streams (above fourth-order) that are prone to wash-outs (Naiman et al., 1988). Most of the streams within the Ware River watershed are first- to second-order streams, although there are larger streams (East and West branches of the Ware River) that are fourth- to fifth-order streams. Any beaver dams located on these higher order streams are much more prone to wash-outs.

The beaver's role in pathogen transmission is addressed separately (see report*, Quabbin and Wachusett Watersheds Aquatic Mammal Pathogen Control Zone Report, 1999*), and beaver are intensively managed by the Division when colonies are located within the defined Pathogen Control Zones at Quabbin or Wachusett reservoirs. There is no Pathogen Control Zone at the Ware River because the Ware River watershed lacks a terminal reservoir and its water is diverted to either Quabbin or Wachusett Reservoirs. Beaver located on the Ware River watershed (unless otherwise determined) are not assumed to be contributing to water degradation with regards to pathogen transmission or amplification.

The role of beaver in riparian systems was reviewed and is summarized below. The effects of beaver on riparian vegetation, water quality parameters, and ecology are discussed.

6.5.1.2.1 Beaver Impacts on Riparian Vegetation

Beaver are strictly herbivores and have been described as choosy generalists (Novak, 1987). Beaver are also central place foragers because they return to their lodge or bank den after feeding (Naiman et al., 1988). This is an important behavioral trait and as a result, beaver foraging is restricted to a relatively narrow band of forest surrounding their pond (Johnston and Naiman, 1990). One study indicated that beaver fed preferentially on a small number of deciduous species and the number of stems cut declined sharply as distance increased from the pond (Donker and Fryxell, 1999). Barnes and Mallik (2001) found that 91% of all beaver cut stems were within 20.1 meters of the pond shoreline. Beaver will cut and consume a variety of woody vegetation in addition to feeding on aquatic vegetation during the spring and summer. Beaver have a strong preference for certain species, particularly members of the aspen family.

When beaver colonize a new riparian area, several important events take place. Typically, a dam is constructed across a stream, raising the water level. The raised water level kills trees within the flooded zone. In addition, beaver cut down trees along the shoreline. Although a substantial number of trees may be lost due to flooding, the wetland continues to be buffered by a forested habitat. The forested zone has been pushed back to the new high water level, as opposed to lining the original stream bank. Along the shoreline, some canopy trees are killed or toppled by beaver, allowing more light to reach the forest floor. Increased light from overstory removals, along with a decrease in competition for water and nutrients, will stimulate regeneration and a release of the forest understory (Johnston and Naiman, 1990). The light penetration may be sufficient to allow regeneration of shade-intolerant species (Donker and Fryxell, 1999).

The amount of canopy being removed along the shoreline can vary. After 6 years of continuous occupation, one study site had a 43% reduction in basal area of stems >2 inches dbh within the shoreline area (Johnston and Naiman, 1990). Other studies have indicated that perceived damage and actual damage to forest resources may be quite different. King et al. (1998) described the effect that beaver in a wetland in the southern United States were having on the forest. In this case it was determined that although tree damage adjacent to the wetland was highly visible by casual observation, beaver were having little impact on landscape-level tree survival.

In some cases where the overstory is primarily comprised of aspen or poplar, a majority of the overstory may be removed, and the riparian area may go through a shrubby/woody stage until non-browsed species grow and overtop the shrub layer. On the Ware River watershed, aspen species are a relatively minor component of forested riparian areas. Most riparian areas consist of a diversity of species, making it less likely that all trees will be removed, although the shrubby component of the riparian area may become more dominant as some canopy trees are lost. Beaver-induced changes to vegetation along riparian zones can be quite dramatic when compared to conditions prior to beaver occupation. The primary result of these changes will be a shift in the species composition before and after beaver occupation. In summary, the riparian wetland, although different following beaver occupation, is still buffered by a partially forested habitat that may contain a larger shrubby component.

6.5.1.2.2 Beaver Impacts on Water Quality

As mentioned previously, the Division does not manage beaver within the Ware River watershed to control pathogen transmission. However, because beaver can alter the hydrologic regime of riparian areas, it is important to consider their impacts with regards to general water quality parameters. As mentioned previously, most streams within the Ware River watershed are low-order (first-to-third) systems, and thus beaver dams constructed in these sites are likely to exist in stable conditions for many years.

In many situations, beaver dams can transform a lotic (moving) system into a lentic (still) habitat that may resemble a lake or pond (Hammerson, 1994). Some important changes associated with this transformation include increased water depth, elevation of the water table, an increase in the wetted surface area of the channel, and increased storage of precipitation, which is more gradually released. In addition, the storage of precipitation can reduce variability in the discharge regime of the stream. In low-order streams there is a shift to anaerobic biogeochemical cycles in soil layers beneath the aerobic pond sediments.

Ponded areas behind beaver dams reduce current velocity, which decreases erosion and stabilizes streambanks (Brayton 1984, Hammerson 1994). In some western states beaver were introduced into riparian ecosystems with eroded streambanks and little vegetation along the shoreline (Brayton 1984). The result was a dramatic decrease in sediment transport downstream, streambank erosion was stabilized, and the diversity of vegetation began to increase (Brayton 1984). In addition, by slowing water velocity there is increased trapping of sediments behind beaver dams, and a resultant decrease in turbidity downstream (Brayton 1984, Hammerson 1994, Maret et al., 1987, Naiman et al.,1994, Naiman et al.,1988). Several studies have shown a substantial amount of sediment being collected behind beaver dams, ranging from 1.5-6 feet (Hammerson 1994, Meentemeyer and Butler 1999). Meentemeyer and Butler (1999) suggest that if beaver are eliminated from a landscape, basin sediment yields can increase dramatically. Having beaver present in a watershed can help minimize sediment transport and stabilize stream banks (Meentemeyer and Butler 1999).

Some important changes in the chemical and physical properties of the stream occur when an area is dammed. Generally there is a reduction in dissolved oxygen, aluminum, and sulfate, and an increase in pH, dissolved organic compounds, iron, and manganese (Smith et al., 1991, Hammerson 1994). Dissolved oxygen reduction is most likely the result of increased retention of organic matter and associated decomposition processes (which use oxygen) (Smith et al., 1991). By retaining large amounts of sediment and particulates, beaver ponds can also trap nutrients associated with sediments, including phosphorus (Maret et al., 1987). Other studies have shown that beaver activities may increase concentrations of phosphorus within the impoundment (Klotz 1998). However, in these studies it is clearly shown that increased concentrations of phosphorous only occur for short distances downstream of beaver ponds before equilibrium processes reduce the concentration (Klotz 1998). Phosphorus is an important element in water supply reservoirs because it is often the limiting factor in the growth of aquatic plants and algae in reservoir systems (Lyons 1998). Thus, the more P that is available in the system, the greater will be the growth of algae.

A potential problem associated with beaver is the increase in dissolved organic carbon (DOC) within the beaver pond. Though DOC does not directly affect drinking water quality parameters, it is a water quality concern because increased DOC can increase disinfection by-products in chlorinated systems. DOC in beaver ponds increases for several reasons. First, a large amount of wood is transferred into the stream channel, either directly through cutting or indirectly through flooding. In addition, more leaves are collected within a pond than in a stream channel. The carbon turnover rate for this material is less in a ponded area than in a stream with flowing water Hammerson 1994). Margolis et al.,(2001) found average DOC concentrations 10 meters and 100 meters downstream of a beaver impoundment were significantly higher than DOC concentrations upstream of a beaver pond. Although increases in DOC are a potential concern, a recent study at Quabbin suggested that biological processes and the sheer size of the reservoir prevented these elevated DOC levels in the tributaries from reaching the intakes (Garvey 2000). In fact, this study suggests that algae are a much greater concern regarding disinfection by-products at reservoir intakes than elevated DOCs in watershed tributaries.

The overall effect of the ponding of riparian areas is the translocation of chemical elements from the inundated upland to the pond sediments or downstream. A portion of the chemical elements are transported downstream, while most are accumulated in the pond sediments and are available for vegetative growth if the pond drains and succession begins (Naiman et al., 1994).

6.5.1.2.3 Ecological Changes Associated with Beaver

As the beaver transforms the stream channel into a ponded area, various ecological changes result. The most immediate effect could be the potential loss of habitat for species either requiring large expanses of deciduous trees along a stream or those species living within the stream channel. Because a beaver dam influences only parts of a stream course, it is unlikely that beaver activity would result in the disappearance of species relying on wooded streams. In New York, experts agree that even after 30 years of expanding beaver populations, species or communities requiring wooded wetlands were probably not adversely affected on a regional or statewide level (Hammerson, 1994).

There is often a good deal of concern regarding the impacts of beaver impoundments on cold water fisheries. It is likely that beaver both enhance and degrade fish habitat. Hägglund and Sjöberg (1999) indicated that beaver enhance fish species diversity in Swedish streams. In addition, they speculate that beaver ponds serve as habitat for larger trout in small streams during drought periods. Snodgrass and Meffe (1998) indicated that in low-order streams, beaver had a positive effect on fish species richness. However, on a landscape level, such positive effects are dependent upon a dynamic pattern of beaver pond creation and abandonment over time.

The warming of stream water is often cited as a cause of concern regarding cold water fish habitat. A study done in Maryland and Pennsylvania reported that water temperatures were significantly warmer downstream of beaver dams during the fall, spring, and summer (Margolis et al., 2001). McRae and Edwards (1999) indicated that large beaver impoundments would often warm downstream temperatures slightly, but they also served to dampen temperature fluctuations immediately downstream. In addition, when beaver dams were experimentally removed, the difference between upstream and downstream temperatures was unchanged, although in some cases, dam removal increased the warming rate of the stream (McRae and Edwards 1999). It has been suggested that in the absence of direct thermal inputs, ambient air temperature (not the presence of impoundments) is the single most important determinant of stream temperature (McRae and Edwards 1999).

The impacts on other organisms resulting from stream channel transformation by beaver are less well understood. For example, Russell et al. (1999) reported that species richness and abundance of amphibians were not significantly different among old beaver ponds, new beaver ponds, and unimpounded streams. Reptiles did show a difference among sites. Richness and total abundance of reptiles was significantly higher at old beaver ponds (Russell et al., 1999). Another study found no significant differences in overall herpetofaunal abundance between uninterrupted streams and beaver ponds (Metts et al., 2001). However, significantly more salamanders were captured at uninterrupted streams and significantly more anurans, lizards, and turtles were captured at beaver ponds (Metts et al., 2001).

Invertebrate communities exhibit strong ecological shifts as running water taxa are replaced by pond taxa when streams are impounded. This results in an increase in the number of collectors and predators and a decrease in the number of shredders and scrapers (Naiman et al., 1988). While total density and biomass may be 2-5 times greater in ponds than in riffles, the total number of species in ponds and streams appear to be similar (Naiman et al., 1988).

6.5.1.3 Summary

Beaver populations within the Ware River watershed continue to expand as beaver mortality rates remain low. As beaver continue to colonize riparian areas, it is important to recognize their role in hydrologic and ecological processes. A careful review of the literature would indicate that it is not the presence of beaver dams but their persistence through time that has the greatest potential impact on water quality. The results of one study suggested that beaver ponds could improve water quality if they were in the right locations (Maret et al., 1987). This study suggested that it was really the downstream channel that had the largest impact on water quality, as the authors state:

> Our data illustrate the importance of location of beaver ponds along a stream in improving water quality. If water quality is to be maintained downstream from ponds and if nutrient export to a lake or reservoir is to be reduced, then the channel downstream from the pond complex must be stable or the pond complex must be located close to the lake or reservoir.

Most streams within the Ware River watershed are low-order (first to third), and beaver dams constructed across these streams have the strong potential for long-term stability and persistence. On those sites with historically unstable beaver dams or on particularly "flashy" streams, beaver control may be necessary to prevent water quality degradation associated with dam instability.

Some water quality parameters are modified when beaver construct dams in riparian areas. Generally, there is a reduction in dissolved oxygen, and in increase in dissolved organic carbon, pH, and iron. Some studies have suggested that these changes may carry at least 100 m downstream of an impoundment. There is also some evidence to suggest that beaver ponds (like most wetlands) may have a filtering effect that improves water quality by decreasing erosion, and trapping sediments, particulates, and nutrients. Changes to vegetation along the banks of beaver ponds result in a species shift away from those species preferred by beaver to a larger proportion of woody shrubs and unpalatable or undesirable (by beaver) canopy trees. The more open canopy that results from beaver activity stimulates regeneration and increases habitat diversity.

Overall, there appears to be either no effects or positive effects on faunal species richness and diversity when comparing ponds to unaltered riparian wetlands. There are still site-specific situations where beaver will need to be controlled as detailed in the next section. Outside these specific situations where damage is occurring, there does not appear to be a need for the Division to focus beaver control efforts on a watershed basis. It should be highlighted that recreational trapping has historically been allowed on Division land within the Ware River watershed and continues to be a permissible activity. However, with recent restrictions on the types of traps allowed, there has been little watershed-wide trapping conducted since 1996.

6.5.1.4 Management Policy

Beaver management issues within the Ware River watershed can be broken down into two categories: Water Quality Protection and Damage to Structures or Resources. In both cases, the general policy of the Division is to evaluate and deal with beaver issues on a site-specific, case-by-case basis.

6.5.1.4.1 Water Quality Protection

There is consensus in the scientific community that beaver can play an important role in the transmission of harmful pathogens to humans through water supplies. The Division recently completed a report that summarizes these concerns and addresses management recommendations for beaver at both the Wachusett and Quabbin watershed reservoirs. For more detailed information regarding this see the report titled, *Quabbin and Wachusett Reservoirs Watersheds Aquatic Wildlife Pathogen Control Zones.* This report clearly defines a protection zone around each reservoir where beaver will be eliminated and excluded on a continual basis for water quality protection. That report does not address beaver management for water quality protection within the Ware River watershed. As discussed before, the Ware River watershed does not include a terminal reservoir. As a result, no defined control zone exists. If a situation arises where water quality is being threatened, then these situations will be handled on a case-by-case basis and mitigation may be required.

6.5.1.4.2 Damage to Structures or Resources

Watershed-wide beaver population control is not conducted by the Division. However, the following situations are examples where beaver activity may be discouraged, mitigated, or otherwise controlled:

- Beaver activity that threatens rare or uncommon plant or animal communities.
- Beaver activity that precludes the use of access roads necessary for watershed maintenance, management, or protection.
- Beaver activity that threatens the proper functioning or structure of dams, culverts, and other parts of the water supply infrastructure.
- Beaver dams on unstable or flashy streams with a history of, or potential for, regular washouts.

When there is a conflict with a beaver colony, the following procedure will be used to mitigate the damage. Division personnel encountering problem beaver sites should complete a Beaver Damage Observation Form and return it to the Division wildlife biologist and Quabbin/Ware River section superintendent. Upon review, the wildlife biologist and superintendent will decide the most appropriate control activity for each site. Guidelines for determining proper mitigation are discussed in the following section. Appropriate permits will be obtained when they are necessary (e.g., removing a section of dam to install a flow control pipe). Specific guidelines will be followed when lethal measures are determined to be the best alternative to alleviate the problem.

6.5.1.5 Guidelines for Determining Proper Mitigation for Problem Beaver

When a Beaver Damage Observation Form is received by the Division wildlife biologist and Quabbin/Ware River Superintendent, they will decide on the most appropriate control activity for that particular site. Options available include water level control devices, dam stabilization, culvert protection, or lethal removal. Site-specific control options will be chosen based on site conditions, history of the site, and type of damage occurring. The goal is to provide the most effective control possible that mitigates the problem. Lethal removal will be a viable option, but will only be used if all of the following criteria for the site are met:

- Beaver are causing documented (recorded observation, photographs, etc.) damage to Division infrastructure (roads, culverts, bridges).
- Other, non-lethal means (water level control devices, fencing, etc.) would not adequately mitigate the problem because of limitations in access, maintenance, or effectiveness.
- The Division property being damaged is essential and cannot be temporarily abandoned.
- Lethal measures can be implemented within appropriate laws and guidelines and without threat to the safety of the public, domestic animals or other wildlife.

When lethal measures are to be used, the following procedure must be followed:

- The above criteria must be documented (using Beaver Damage Observation Form) prior to any action.
- Whenever possible, local licensed trappers will be used to remove the animal(s) during regular state trapping seasons.
- Beaver will be removed through shooting (12 gauge shotgun), or live-trapping using Hancock, Bailey or cage traps and then shooting.
- All staff involved in lethal beaver control will have necessary training and licenses.
- Every attempt will be made to retrieve beaver carcasses, which will be buried at a suitable location.
- Personnel taking part in beaver control activities will take adequate precautions (washing hands/wearing rubber gloves) to prevent possible transmission of Giardia and Cryptosporidium and other pathogens.

- The supervisor in charge will document all actions and complete the proper form (Beaver Removal Documentation Form), copies of which will be sent to the Wildlife Biologist and Superintendent.

6.5.2 White-Tailed Deer

White-tailed deer populations are increasing in most of the northeast. There is growing concern about these increasing populations and their impact on natural resources (Healy 1999, Alverson and Walker, 1999, McShea and Rappole, 1999). Deer populations within Massachusetts are increasing in the central and eastern part of the state (MassWildlife, pers. comm.). White-tailed deer can thrive in suburban environments where there is abundant food, few predators, and enough wooded areas to provide cover. Coupled with expanding deer populations is increased fragmentation of the landscape that can create wooded reserves that in many cases prevent people from effectively hunting white-tailed deer populations. Even in areas where hunting is feasible, there is growing concern that both hunter interest and hunter recruitment is declining. In many situations, these circumstances can lead to overabundant deer densities.

Overabundant deer populations can influence the abundance of woody plant species (Walker and Alverson, 1997). In addition, intensive deer browsing may cause problems in regenerating particular species, such as oak. When deer populations are protected for many years and sustained at high densities, forest structure may be significantly altered, resulting in park-like stands with grass or ferns dominating the understory (Walker and Alverson, 1997). Situations like this have been documented on the Quabbin Reservation and in the Alleghany National Forest in northwest Pennsylvania (Walker and Alverson, 1997). Because deer hunting has been allowed on the Ware River watershed throughout Division control and before, such extreme conditions are unlikely to develop. However, if deer densities on Division land within the Ware River increase and remain high, then tree species preferred by deer may be affected, causing concern about both the density and the diversity of regeneration in forest stands.

Deer populations within Deer Management Zone 8 (encompassing most of the Ware River watershed) are estimated at 12-15 deer/mi^2. Deer populations within the Ware River watershed are estimated to be slightly higher, around 15-17 per mi^2 (MassWildlife, pers. comm.) due to large areas of quality habitat that has resulted from the Division's land management activities. There is growing concern about the declining hunter base and poor hunter recruitment that could impact both the number and distribution of deer kills within the watershed.

The Division's primary concern is to limit the impact of deer on tree regeneration and growth. The Division does not yet scientifically monitor forest regeneration or deer populations within the Ware River watershed. However, Ware River foresters routinely walk and inspect a variety of forest stands and sites within the watershed and make anecdotal observations about regeneration, including observed changes in diversity of species.

Given the trend of rising deer populations, shrinking hunting opportunities, and a declining hunter base, the Division recognizes the potential for some of its lands to experience overabundant deer populations. Although primarily focused on the impacts of overabundant deer on tree regeneration, the

Division also recognizes that other social issues related to overabundant deer may become more prevalent. These include increased deer/vehicle collisions and personal property damage. As a result, the Division will examine the feasibility of initiating long-term monitoring of both deer herd dynamics and tree regeneration across the watershed. Regeneration plots would be established and monitored to scientifically assess the impact of white-tailed deer browsing on tree regeneration and growth. In addition, surveys may be initiated to monitor deer population trends over time. The Division would collaborate with MassWildlife to design appropriate methods to index the deer population

6.5.3 Moose

Moose are North America's largest wild animal. An average adult moose weighs about 1,000 pounds and stands 6 feet at the shoulder. Moose and their ancestors originated in Siberia and made their way to North America across the Bering Sea land bridge. At the time of European settlement, moose were distributed from Alaska, across Canada into the northern United States from North Dakota east to Pennsylvania and all of New England, including Massachusetts. Moose also extended down the Rocky Mountains in the West. Temperature was probably the limiting factor in the southern distribution of moose in North America. Winter stress typically occurs when temperatures exceed 23°F and summer stress when temperatures are >59°F (Franzmann and Schwartz, 1997).

Moose were extirpated from Massachusetts by the early to mid- 1800s (Peek and Morris, 1998, Veccillio et al., 1993). A small number of moose escaped from a game preserve in Berskshire County around 1911 and may have persisted for several years (Veccillio et al., 1993). Most sightings during the next 50 years were probably northern vagrants. Since the late 1980s, the number of moose sightings has increased greatly (Peek and Morris, 1998). In 1998, the moose population in Massachusetts was estimated as at least 75 animals including cows with calves (Peek and Morris, 1998). Reasons for the increase in moose populations include the absence of predators, reversion of farms to forested areas, legal protection, increased wetlands from expanding beaver populations, and larger forest openings (Franzmann and Schwartz, 1997).

Moose populations continue to expand in Massachusetts. Division land within the Ware River watershed probably functions as a core habitat for moose populations given its large size and diversity of habitats. In fact, Division land within the Ware River watershed probably supports some of the highest moose densities in the state (B. Woytek, pers. comm.). Moose populations in the state suffer relatively little natural or human-caused mortality. Black bears are the only potential predator of moose and are limited to killing young calves. There are approximately 2,000 black bears in Massachusetts, and most of them are located west of the Connecticut River. As a result, current bear populations are not capable of limiting moose populations.

The main source of moose mortality is most likely from interactions with people. In 1997, twelve moose were killed on roads, four nuisance animals were destroyed, and four were immobilized and relocated (Peek and Morris, 1998). It is likely that moose/vehicle collisions will continue to rise as moose populations expand. Because moose/vehicle collisions are extremely dangerous for both humans and moose it has been suggested that moose are incompatible with an urbanized state such as Massachusetts, and the public's tolerance of moose is limited (Peek and Morris, 1998, Veccillio et al., 1993).

6.5.3.1 Moose and Vegetation

Moose are primarily browsers and feed on the leaves, buds, and twigs of a variety of tree and shrub species. An adult moose can consume 40-60 pounds of browse daily (Snyder 2001). During the summer, moose spend time in lakes and ponds feeding on aquatic plants.

A good deal of work has been done assessing the impact of moose on boreal forest ecosystems (Danell et al., 1991, Edenius, 1994, Angelstam et al., 2000, Connor et al., 2000, McLaren et al., 2000, Brandner et al., 1990, McInnes et al., 1992). There exists little if any information on the impact of moose in the southern portion of their range. While boreal ecosystems are relatively simple in terms of species diversity and structure, forests in Massachusetts are much more complex in both composition and processes. While information regarding moose in boreal ecosystems is important and insightful, it does not necessarily represent moose in mixed hardwood/softwood forests.

In Europe, moose were shown to have negative impacts on the quantity and quality of Scots pine (Angelstam et al., 2000). Moose density was found to be the main factor affecting the amount of moose related damage (Angelstam et al., 2000). A study in a Newfoundland park suggested that moose have changed species composition and influenced forest succession (Conner et al., 2000). Hunting has been prohibited in the park since 1974, and natural predation by black bears has not had an impact on the moose population (Conner et al., 2000). Several studies have examined the interaction of moose and Balsam fir, a preferred winter food of moose. In order to successfully regenerate Balsam fir in Newfoundland, McLaren et al., (2000) had to maintain high hunter harvest until trees were >3 meters in height. McLaren et al., (2000) concluded that since wolves were extirpated from Newfoundland, hunting has been the only option to reduce moose populations. McInnes et al., (1992) concluded that moose in the boreal forests of Michigan prevented saplings of preferred species from growing into the canopy. Further, it appeared that browsing by moose influenced the long-term structure and dynamics of the boreal forest ecosystem (McInnes et al., 1992).

Compared to the relatively simple ecosystem of the boreal forest, Massachusetts's forests are comprised of a diversity of hardwood and softwood species. The impact of moose on any particular species is unknown. However, there is substantial evidence linking overabundant deer populations in hardwood forests with negative environmental impacts (McShea et al., 1998). If moose populations continue to expand, the potential exists for moose to impact forest ecosystem structure and function. Localized browsing damage has already been anecdotally noted, particularly during winter weather when moose mobility is more limited and browse pressure becomes locally intense.

6.5.3.2 Monitoring

Because moose populations are expanding in Massachusetts and little is known about the potential impacts of moose on forest ecosystems, it is important to monitor moose populations. To date, monitoring done by biologists at MassWildlife consists of recording road kills, nuisance reports, and a preliminary radio-telemetry study. While this method gives a crude index of relative abundance, it does not monitor population density or reproductive characteristics.

In April 2002, the Division began a moose monitoring program on the Ware River watershed (MDC 2002) to provide information on the relative abundance of moose populations within each study area. Monitoring will continue yearly on the Ware River and will gradually spread to other Division watersheds.

7 Management to Protect the Natural Landscape on DCR/DWSP Property

7.1 Biodiversity Mandate

Congress passed the Endangered Species Act in 1973 to provide federal protection for 292 declining species, and began to legally define the national commitment to maintaining biodiversity in the process. The ESA specifically protected 27 plant and animal species in Massachusetts, and provided both the impetus and funding to restore popular species such as peregrine falcons and the bald eagles in the state. Subsequent to the passage of the ESA, Massachusetts has added additional statewide legal protection for biodiversity. Both MGL ch. 131 (the Wetlands Protection Act) and ch. 132 (the Forest Cutting Practices Act) require regulatory bodies to consider impacts on habitat and species during proposed development or management activities. Massachusetts passed its own Endangered Species Act in 1990, providing protection currently for 424 plant and animal species. This act provides regulatory protection for significant habitats of the listed species, as well as direct protection for the species.

In recent years, the protection of biodiversity has become a high priority for state agencies in Massachusetts. Massachusetts is a diverse environment that currently supports at least 15,000 native species of plants and animals (including about 12,000 insects). MassWildlife (previously the Division of Fisheries and Wildlife) currently operates the Natural Heritage and Endangered Species Program, the goal of which is to protect the state's native biological diversity. MassWildlife also recently launched the "Biodiversity Initiative," in order to coordinate two new programs that were created by the 1996 Open Space Bond Bill (Chapter 15, Acts of 1996). These programs include the Ecological Restoration Program and the Upland Habitat Management Program. The Ecological Restoration Program's major goal is to "focus future restoration action on the fundamental problems threatening biodiversity, including the restoration of natural processes and native community composition." To achieve this goal, the Ecological Restoration Program intends to follow the following strategies:

- Conserve species before they become rare by protecting their habitat.
- Restore natural processes that sustain biodiversity at key sites.
- Limit invasion by exotic or invasive species.
- Replicate natural processes, where they cannot be maintained or restored, at appropriate times, places, and in justifiable quantities.
- Consider species reintroduction only when species' requirements and causes of extirpation are sufficiently understood, and carefully consider the costs and benefits.

The Natural Heritage Program, in conjunction with the Massachusetts Chapter of The Nature Conservancy published "Our Irreplaceable Heritage: Protecting Biodiversity in Massachusetts" in 1998. This document outlines a Biodiversity Protection Strategy that includes the following:

- Encourage all conservation agencies, land trusts, municipalities, and not-for-profit conservation organizations to increase the importance given to and financial support for the conservation of uncommon and under-protected components of biodiversity.
- Educate landowners about maintaining and restoring certain natural processes and minimizing disturbance.
- Aid land managers in implementing land management techniques that mimic natural processes where they cannot be maintained or restored.

- Strive to achieve an equitable distribution of biologically viable conservation lands at all topographic elevations and across all ecoregions.
- Take action to conserve natural communities and species that have experienced tremendous loss or are under considerable threat.
- Focus attention on common or rare natural communities and species that are under-protected.

The April 2000 "The State of Our Environment" report from the Massachusetts Executive Office of Environmental Affairs (EOEA), acknowledged the link between human needs and healthy, thriving natural communities. EOEA identified loss of habitat through development, and invasive species as the two most distinct threats to maintaining natural diversity in Massachusetts, and further committed to preserving biodiversity through the identification and protection of critical habitats and the creation of bioreserves that will include central cores of public land. Specific to public forestland, EOEA has completed a Forest Vision Project that sets priorities for a biodiversity-based management approach, and is currently working to develop landscape-level guidance documents for each ecoregion in the state, as part of sustainability certification of all state forest management.

DCR Division of Water Supply Protection mandates (stated in MGL ch. 92) and Special Acts of the Legislature (including c. 372 of 1984, and c. 737 of 1972) are directed at the production and protection of high quality drinking water for metropolitan Boston. However, these laws also set forth a broad commitment to the protection of natural resources and species diversity. Chapter 737 addresses the management of Quabbin and Ware River Watersheds, and includes the following broad mandates:

> Section 2: The natural ecology of the district shall be maintained and it shall be conserved in the present degree of wilderness character...[it] shall be protected in its flora and fauna in all reasonable ways…no act shall be undertaken which will adversely affect the balance of nature…
>
> Section 8: Lumbering or logging operations shall be permitted…to the extent and for the purpose of maintaining and conserving its forests in a healthful state of natural ecological balance consistent with reservoir and watershed purposes…

The Division's principal goals for maintaining biodiversity on its Ware River watershed holdings are to retain most of these lands in a forested condition, to identify and provide habitat for the protection of uncommon and rare flora and fauna, to eliminate and prevent the spread of non-native invasive species, and to provide the range of seral stages from early-successional habitat through unmanaged mature forest.

7.2 Rare Natural Communities

A natural community is a combination of physical and biotic conditions that form a functionally distinct area of the landscape. An area's physical conditions (topography, hydrology, geology, etc.) will determine the vegetative composition, which in turn will dictate the type of animal community that lives there. Ideally, to adequately protect and enhance these communities, all features of the system must be properly protected and enhanced, not just individual parts.

Natural communities may be rare or uncommon globally, statewide, or at a local level. To ensure all rare communities receive adequate protection it is necessary to know where the communities are located on the landscape. Unfortunately, the Division has little information regarding rare or exemplary communities within the Ware River watershed. Some communities (e.g., vernal pools) are known and documented. In addition, the NHESP has limited records of rare species or communities known to occur on the watershed. Still, most communities considered rare or exemplary on a local or regional level have not been mapped.

The Division's first step in managing rare natural communities will be to properly classify rare, unique, and exemplary communities that may occur within the watershed. When the classification system has been established, mapping can begin to locate potential communities. Field inspections will then be required to verify mapped areas. Management will be modified as needed to maintain the integrity of the area.

A project to map rare, unique, and exemplary natural communities was recently conducted on the Quabbin Reservoir watershed. A classification system tailored to Quabbin communities was developed and preliminary field verifications were conducted. Mapping and management recommendations for each community were completed. Some information from the Quabbin study can be utilized at the Ware River, since many of the communities are rare or unique on a statewide or regional level. For example, talus slopes, pitch pine-scrub oak, hemlock ravines, tupelo swamps, vernal pools, and peat wetlands, identified as rare communities at Quabbin also occur on the Ware River watershed. A complete census of Division land is necessary to accurately inventory community types.

7.3 Rare and Endangered Species

7.3.1 Fauna

Division property within the Ware River watershed is home to a number of state-listed vertebrate species (Table 16). However, because the Division's land holdings are protected from development, it is possible that past rare animal surveys bypassed Division land. Thus, it is likely that there are additional undiscovered populations of rare and endangered species on Division property. In fact, most documented rare species within the Ware River watershed have not been observed on Division property. Although land protection is the most critical factor for survival, it would be very helpful to know where these species are located. The Division does actively manage its landholdings, and therefore there is the potential for these activities to have negative impacts on rare species. In addition, some species may require additional management in order to enhance or modify existing habitat to benefit their survival.

In order to ensure that land management activities do not disrupt or destroy listed species or their habitats, an accurate and current species occurrence database must be available and expanded. The Division biologists keep records of listed species on Division land that were discovered by in-house personnel or by the general public. The state's Natural Heritage and Endangered Species Program has much more complete and detailed databases of listed species. In some cases, land management activities carried out by the Division (e.g., Ch. 132 forest cutting plan) are reviewed by NHESP. Other activities, such as routine maintenance (mowing, brush cutting) or watershed maintenance activities (road building/repair) are conducted without a requirement to notify NHESP. In these situations, it is possible to unknowingly and negatively impact rare or endangered species. Again, this points to the need for additional rare species surveys (see Section 6.3), particularly on recently acquired parcels where little is known about the land.

In many cases, species become rare because of loss of habitat. One of the greatest benefits of Division land to wildlife is that it will remain in a natural state and not be developed. A majority of this habitat will be covered by forest. This is a benefit to rare or endangered species requiring forested habitat (e.g., sharp-shinned hawk, Cooper's hawk) but will not help other species that require different habitat, such as fields (e.g., bobolink, Eastern meadowlark). Approximately half the species listed in Table 16 are either dependent on wetlands or utilize them during some portion of their lives. Protecting and maintaining functioning wetland systems is a priority for the Division, and this priority should benefit wetland species. In addition, vernal pools on Division land receive particular attention and protection (see section 6.3.1). Current MA BMPs for vernal pools are being studied to determine their effectiveness in protecting vernal pool dependent species.

Non-forested upland habitat is much rarer on Division property and is limited to maintained open fields. There are several species on Table 16 that require open fields or meadows. Although the Division will not create field habitat, it does recognize the importance of this habitat in the landscape. Therefore, where feasible, the Division will maintain and enhance this habitat on select portions of its land (see Section 7.5.3).

Areas with highly disturbed soils represent important habitat for several species listed in Table 16. There are several large, active and inactive gravel and sand pits on Division land, as well as areas of stream and shoreline erosion, and abandoned industrial/residential land. Wood and box turtles use sandy or gravelly areas to lay their eggs. In addition, some invertebrates, such as the big sand tiger beetle, dune ghost tiger beetle, oblique lined tiger beetle, frosted elfin and hoary elfin, utilize areas of highly disturbed soils. The Division recently documented wood turtles laying eggs in an abandoned Division sand pit. In many cases, however, these highly disturbed areas are scheduled for restoration. The Division recognizes the potential wildlife value some of these areas have, and in the future the Division will examine each site on a case-by-case basis to determine actual erosion threat, and habitat suitability for selected wildlife species. In some cases, where erosion is not a threat, the site can be abandoned and left in its disturbed state.

Some species listed in Table 16 are assisted by habitat protection, but still need additional assistance to successfully breed. In these cases, when personnel and resources allow, the Division may provide the needed breeding structures or other conditions. When possible, the Division may provide nesting boxes for long-eared owls, and erect nesting structures for bald eagles.

7.3.2 Flora

Primary responsibility in Massachusetts for the protection of endangered, threatened, or special concern plant species rests with the Natural Heritage and Endangered Species Program of the Department of Fish and Game. NHESP has identified 257 species of plants in these categories across the state, and is working continually to design effective protection strategies. Regulatory support for these efforts exists at both the federal and the state level. The Federal Endangered Species Act of 1973 protects 292 species of national significance, which includes the small-whorled pogonia (*Isotria medeoloides*) that is found in Massachusetts. Additional protection was provided by the 1990 Massachusetts Endangered Species Act, which protects a total of 424 species, of which 250 are plants.

Plants are considered rare for a variety of reasons. In some cases, it is simply that Massachusetts is at the northern limit (e.g., Black maple, *Acer nigrum* or River birch, *Betula nigra*) or the southern limit (e.g., Dwarf rattlesnake plantain, *Goodyera repens* or One-flowered pyrola, *Moneses uniflora*) of their range. For species that are generally associated with the eastern deciduous forest, which dominates central and western Massachusetts, plants may be rare simply because they are poor colonizers and thus populations remain widely scattered and sparse. Loss of habitat is also a common cause of plant species loss. Bruce Sorrie, former Massachusetts state botanist, estimated that a surprising 72% of the species extirpated from the state had been lost due simply to the loss of early-successional or recently disturbed habitat (Sorrie, 1989). Karen Searcy, current curator of the University of Massachusetts herbarium, reported in 1995 that 13% of the rare species likely to occur on Division properties rely on early-successional habitat or disturbance such as fire to persist (Searcy, 1995). Animal populations are

TABLE 16: STATE-LISTED VERTEBRATE SPECIES IN THE WARE RIVER WATERSHED

SPECIES	STATUS[1]	OCCURRENCE[2]
AMPHIBIANS		
Blue-Spotted Salamander	SC	Probable
Marbled Salamander	T	Probable
Spring Salamander	SC	Probable
Four-Toed Salamander	SC	Documented
Eastern Spadefoot	T	Potential
REPTILES		
Spotted Turtle	SC	Probable
Wood Turtle	SC	Documented
Blanding's Turtle	T	Probable
Eastern Box Turtle	SC	Documented
Copperhead	E	Historic
Timber Rattlesnake	E	Historic
BIRDS[3]		
Common Loon	SC	Potential
Pied-Billed Grebe	E	Potential
American Bittern	E	Documented
Least Bittern	E	Potential
Bald Eagle	E	Potential
Northern Harrier	T	Potential
Sharp-Shinned Hawk	SC	Probable
Cooper's Hawk	SC	Probable
King Rail	T	Potential
Upland Sandpiper	E	Historic
Common Barn Owl	SC	Historic
Long-Eared Owl	SC	Probable
Short-Eared Owl	E	Historic
Sedge Wren	E	Historic
Golden-Winged Warbler	E	Historic
Vesper Sparrow	T	Probable
Grasshopper Sparrow	T	Probable
Henslow's Sparrow	E	Historic
MAMMALS		
Water Shrew	SC	Probable
Southern Bog Lemming	SC	Probable

[1] Species status in Massachusetts: SC= species documented to have suffered a decline that could threaten the species if allowed to continue unchecked; T = species likely to become endangered within the foreseeable future throughout all or a significant portion of its range; E = species in danger of extinction throughout all or a significant portion of its range.
[2] Occurrence of species on Division land within the watershed: Documented =species actually observed; Probable =species not documented, but given available habitat, species' range, and/or observations within the watershed, they are likely to occur; Potential =species not documented, and current habitat conditions may not be suitable, but with habitat enhancement they may occur; Historic= species not documented, and current or future habitat conditions are not likely to support these species.
[3] Occurrence of birds is limited to breeding pairs, not migratory or seasonal residents.

responsible for some losses, either through heavy browsing or through dramatic habitat alterations such as those caused by beaver. While beaver wetlands may provide habitat for some rare plants, they also flood bogs and other uncommon habitats that may have contained rare plant populations. Some species (e.g., Ginseng, *Pallax quinquefolius* L.) have declined directly because of over-collecting. Invasive, non-native plants have also been implicated in the decline of some uncommon native species.

Management recommendations for protecting rare plant populations begin with efforts to identify current populations. The Division is committed to working to locate these populations and adding them to GIS databases so that they will appear on maps even at times when they are difficult to locate in the field. Several agencies and organizations, including the NHESP in Massachusetts and the Southern New England Forest Consortium, are working to develop specific management recommendations for the perpetuation of uncommon plant species. Much remains to be learned about the specific light, moisture, and regeneration requirements for the species of concern. Some species will persist best if given a wide berth, while others benefit from periodic disturbance. The Division will rely on recommendations being developed to guide management practices around known rare plant populations. For instance, the Southern New England Forest Consortium has recently published "Rare and Endangered Species: Field Guide for Southern New England," which includes management recommendations. The Division will continue to work to identify rare plant populations and to research and apply management recommendations for their protection.

7.4 Biotic Invasions

7.4.1 Definitions

The following definitions are taken from President Clinton's "Executive Order 13112 of February 3, 1999 – Invasive Species."

"Alien species" means, with respect to a particular ecosystem, any species, including its seeds, eggs, spores, or other biological material capable of propagating that species, that is not native to that ecosystem.

"Control" means, as appropriate, eradicating, suppressing, reducing, or managing invasive species populations, preventing spread of invasive species from areas where they are present, and taking steps such as restoration of native species and habitats to reduce the effects of invasive species and to prevent further invasions.

"Ecosystem" means the complex of a community of organisms and its environment.

"Introduction" means the intentional or unintentional escape, release, dissemination, or placement of a species into an ecosystem as a result of human activity.

"Invasive species" means an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health.

"Native species" means, with respect to a particular ecosystem, a species that, other than as a result of an introduction, historically occurred or currently occurs in that ecosystem.

> "Species" means a group of organisms all of which have a high degree of physical and genetic similarity, generally interbreed only among themselves, and show persistent differences from members of allied groups of organisms.

Current research in the field of invasives has documented that animal invaders can cause extinction of native species through habitat alteration, predation, and competition (Mack et al., 2000). Further, plant invaders can completely alter the nutrient cycling, hydrology, and energy budgets in native ecosystems, thereby affecting the abundance or survival of native species (Mack et al., 2000).

Although there are several examples of invasive animals present on the Ware River watershed (e.g., gypsy moth), there are many more invasive plants know to be present, and these represent the greatest immediate risk to native habitats and species. Therefore, DCR/DWSP efforts in controlling invasive species will focus on the control of invasive plants during the next 10 years.

"Invasive" plants fall into at least two categories – native or non-native species. Most of the difficulties associated with invasive plants involve plants that are non-native. This is true in part because these non-native "aliens" have been transported out of the ecosystem in which they evolved, and may have escaped specific population-controlling insects and diseases in the process. It is important to point out that not all non-native plants are invasive. Most have been intentionally introduced into agricultural or horticultural environments, and many are unable to reproduce outside of these intensively managed environments. There are, unfortunately, hundreds of others that were introduced either deliberately or accidentally to natural settings and have managed to aggressively force out native plants, raising serious biodiversity issues, and potential threats to water quality protection.

Some of the invasive plant problems on Division properties are the result of deliberate plantings that initially addressed other concerns, for instance, planting autumn olive to improve wildlife habitat. Other invasive species are escapees from landscaping that predates Commonwealth acquisition of watershed properties, including Japanese barberry, Japanese knotweed, the buckthorns, and purple loosestrife. Several qualities contribute to a plant's "invasiveness":

- The plant grows and matures rapidly in abundantly available habitats.
- It is capable of producing vast quantities of seed that is easily dispersed by animals, and often can also reproduce vegetatively.
- There are no diseases or pests effectively controlling its reproduction and spread (which generally means there are no close relatives in the habitats it invades).
- The plant does not require intensive management to thrive.

Japanese barberry, Berberis thunbergii

7.4.2 Problems Associated with Invasives

The 2000 EOEA report "The State of Our Environment" states that "the two biggest threats to biodiversity in Massachusetts are the destruction and fragmentation of wildlife habitats and the introduction of invasive non-native species." The Nature Conservancy has reported that 42% of the declines of threatened or endangered species in the US are partly or wholly due to the effects of invasive species. Some of these threats are subtle. For instance, when the declining West Virginia white butterfly lays its eggs on the invasive garlic mustard instead of on the usual native mustards, its eggs fail to develop. Other threats are more obvious. For instance, purple loosestrife currently covers an estimated 500,000 acres in northern US and southern Canada, displacing native food sources and threatening to prevent successful nesting in 90% of the wetlands used by breeding waterfowl along the Atlantic and Mississippi flyways. Impacts from invasives on the soil and its faunal community have also been documented. There is evidence that a Chinese tallow tree is altering nutrient cycling where it invades, causing a decline in the native soil invertebrates as a consequence.

Resilient plant communities are important to watershed management for controlling the erosion of soil and nutrients following a range of natural disturbances (e.g., droughts, insect outbreaks, fire, wind, heavy snow and ice). Resilience is partially dependent upon species and size diversity in the plant community, because disturbances are frequently species and/or size specific. When plants become aggressively invasive, they replace the diverse native flora with local monocultures, thereby decreasing the diversity and associated resilience of the community. The prevention of forest regeneration by certain aggressive invasives has become a problem on some areas of the watersheds. Around the Quabbin Reservoir, Japanese barberry that was planted on historic home sites took advantage of high deer populations (which do not feed on barberry) to colonize and monopolize the understories of significant forest areas. At the Wachusett Reservoir, autumn olive has aggressively occupied open fields, delaying or precluding their return to forest cover. Buckthorns are replacing native understory vegetation in some areas on the Ware River watershed. Invasives are often more effective than natives in colonizing disturbed areas, and may overrun young trees that do become established. Table 17 lists invasive plants that are known to be present on the Ware River watershed.


Common buckthorn, Rhamnus cathartica

7.4.3 Management Options

The ultimate goal of an invasive species control program may be to eradicate the non-indigenous species from the region of concern. Eradication is sometimes possible, especially if the species is detected early and attacked quickly. Three factors seem to influence whether an eradication program will be successful (Mack et al., 2000). First, the biology of the target species must be susceptible to control. Second, sufficient resources have to be devoted for a sufficient period of time. Changes in funding levels before the program is complete make eradication impossible. Finally, eradication requires support from both the public and the managing agency.

TABLE 17: INVASIVE PLANTS PRESENT ON THE WARE RIVER WATERSHED

Common Name	Latin Name	Habitat
Black locust	*Robinia pseudoacacia*	Edge of forest/field
Norway maple	*Acer plantanoides*	Forest
Oriental bittersweet	*Celastrus orbiculata*	Forest
Japanese barberry	*Berberis thunbergii*	Forest
Shining buckthorn	*Rhamnus frangula*	Forest
Common buckthorn	*Rhamnus cathartica*	Forest
Honeysuckles	*Lonicera sp.*	Open areas
Autumn olive	*Elaeagnus umbellate*	Open areas
Russian olive	*Elaeagnus augustifolia*	Open areas
Multiflora rose	*Rosa multiflora*	Open areas and edges
Goutweed	*Aegopodium podagraria*	Floodplains, riparian areas
Garlic mustard	*Alliaria petiolata*	Floodplains, disturbed woodlands, roadsides
Phragmites (common reed)	*Phragmites australis*	Wetlands

The features that make a plant invasive also frustrate efforts to control its expansion. Effective control requires the removal or killing of mature plants, but also requires that these removals be timed in such a way that they do not result in further reproduction and spread of the plant. Controls need to be designed around the morphology (form and structure), phenology (effects of climate on flowering and fruiting), and reproductive strategies of specific plants. For instance, while prescribed fire will reduce invasions of conifers in native grasslands, it tends to stimulate growth and reproduction of many other invasive plants. Control methods can be mechanical, biological or chemical:

- Mechanical controls include hand-pulling, girdling, mowing, mulching, tilling, and fire.
- Biological control involves the introduction of a natural enemy of an invasive plant. In most cases, the introduced enemy is itself a non-native species.
- Chemical control is often most efficient and effective, but carries risks of collateral damage to non-target species, as well as risks of water and soil contamination.

Given the biological characteristics of most of the problem plant species at the Ware River, the unpredictability of Division funding, and the moderate support by the public, eradication of well-established invasive plants from Division lands is an unrealistic goal, although control in priority areas is possible. Division staff are currently working to produce a strategic plan for managing invasive plants across the watershed system. Treatment of invasive plants to control or reverse their spread will progress as time and budget allow, from the highest to the lower priority areas.

Prioritizing which species to control and where to control them becomes critically important given the limited resources and personnel available. Therefore, areas will be selected for treatment as follows:

- Areas where invasive plant populations are recently established and limited in extent, so that control is a reasonable expectation.
- Areas of invasive plants that are presenting a direct threat to existing rare or endangered plants or animals. Control will be focused on the area of direct threat.
- Areas where tree regeneration is critical and is being prevented by one or more invasive plant species. This may include riparian zones and other critical protection areas.

7.5 Maintenance of Early-successional Habitat for Landscape Diversity

7.5.1 Importance of Early-successional Habitat

Large-scale historic changes in land use have dramatically impacted the number, type, and extent of open lands within the Ware River watershed. Early-successional habitat was a major component in the landscape prior to European settlement. Evidence suggests that grasslands existed in the Northeast before Europeans arrived, and grassland birds have been a component of avian diversity for a long time (Dettmers and Rosenberg 2000). Beaver activity, wildfires, windstorms, and fires set by Native Americans generated and maintained early-successional habitats.

By the 1800s, grasslands were even more abundant in the northeast as agricultural land dominated the landscape. Since the mid-1800s, the amount of grasslands and open fields has decreased dramatically, causing a similar decrease in many species of plants and animals that depend on open habitat. As farms were abandoned, the open fields and meadows were left undisturbed. Without frequent disturbance such as mowing, burning, or grazing, those grasslands gradually reverted back to forest. In the process, some grassland species, such as the loggerhead shrike and regal fritillary butterfly, were significantly reduced in Massachusetts or even extirpated.

Today, farmland continues to be abandoned or converted to house lots, and the amount of viable open land habitat continues to shrink. The remaining grasslands, particularly large (>100 acres) or clustered fields, are increasingly important to a variety of wildlife. Eastern meadowlark, savanna sparrow, eastern bluebird, and bobolink all use hayfields, meadows, or pastures to forage and raise young. During the fall and winter, fields provide food for migrating sparrows, warblers, larks, and snow buntings. Raptors such as the northern harrier, short-eared owl, and American kestrel hunt in fields for small mammals (meadow voles, meadow jumping mice) and insects. White-tailed deer often graze in fields, and foxes hunt fields for small mammals or rabbits. Finally, butterflies like the monarch, tiger swallowtail, and various fritillaries feed on the nectar of grassland wildflowers.

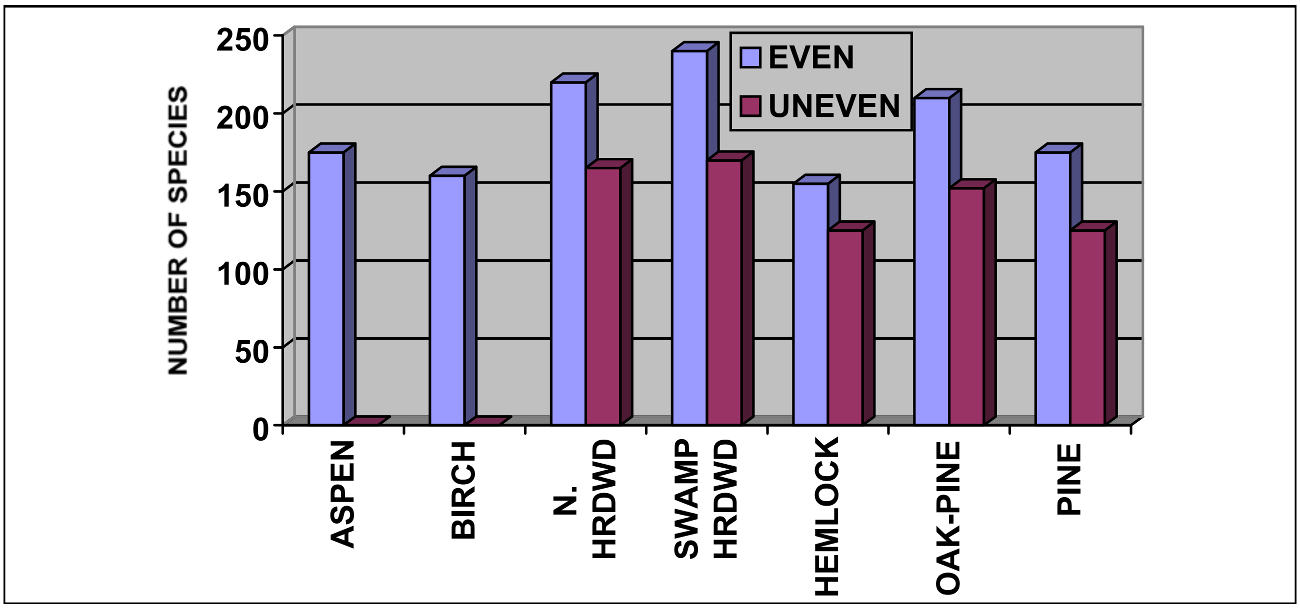
Recent population trends for grassland-dependent species show alarming declines. Bobolinks and grasshopper sparrows have declined 38 and 69 percent, respectively in the last 25 years. Partners in Flight, a national conservation organization, has identified Neotropical migratory bird species of concern in Massachusetts. These species have a high perceived vulnerability (they may or may not be state or federally listed) and are critical to maintaining avifauna diversity in the state. Priority species include Henslow's sparrows, upland sandpipers, grasshopper sparrows, and bobolinks. These species are all associated with grassland habitat.

Early-successional forested habitat is also in decline in Massachusetts. Evidence suggests that early-successional forested habitat was present in sufficient amounts and distributed well enough across the landscape to support long-term populations of early-successional birds in the Northeast prior to either European or Native American intervention (Dettmers and Rosenberg 2000). Fire, major weather events, or beaver activity maintained or generated these habitats across the landscape. European and Native American populations increased the amount of early-successional forested habitat in the region. By the mid 1800s, forest cover in New England had dropped from >90% to <50% (Dettmers and Rosenberg, 2000). As farms were abandoned during the late 1800s, many fields started reverting to forests, and large amounts of early-successional forested habitat became available. Over time, these areas grew beyond the young seral stages used by early-successional species. A survey conducted in 1998 in Massachusetts concluded that only 4 percent of all available timberland was in a seedling-sapling stage (Trani, et al., 2001). Species dependent on these early-successional habitats have experienced further declines in recent decades as the amount of available habitat continues to shrink (Scanlon, 2000).

Partners in Flight has also identified species associated with early-successional forested habitat (e.g., blue-winged warbler, Eastern towhee, and prairie warbler) as high priority species. In addition, New England cottontails, bobcat, woodcock, and northern bobwhite have all experienced declines and are dependent on early-successional habitat (Hunter et al., 2001, Dessecker and McAuley 2001, Litvaitis 2001). Providing habitat for early-successional species involves considerations in both space and time. Early-successional habitats are temporary, generally lasting only 8-15 years. Therefore, either habitats need to be set back on a regular basis or new areas of early-successional habitat need to be created.

Even-aged forest management is the primary technique used to produce early-successional forest stands. This type of silviculture also provides the opportunity to regenerate shade-intolerant species such as aspen and birch. The resulting habitat provides distinct foraging and shelter opportunities for species that are not usually present in forest stands managed under an uneven-aged silvicultural system (DeGraaf et al., 1992). In addition, even-aged management appears to have little effect on mature forest species (Thompson and DeGraaf, 2001). According to DeGraaf, et al. (1992), even-aged management provides habitat for up to 26% more species than uneven-aged management in similar cover types (Fig. 13). Thus, failure to incorporate some even-aged management techniques within the watershed could result in fewer wildlife species. Payne and Bryant (1994) also state that even-aged management tends to support more wildlife species than uneven-aged management in northern hardwoods, hemlock, oak-pine, and pine forests of the northeast. The current level of tree harvesting within the state is relatively light, widely dispersed, and generally does not provide substantial early-seral habitat. Where water supply protection does not preclude it, the Division will try to incorporate management techniques that meet primary management goals while creating this type of habitat. Utilizing a range or combination of silvicultural treatments can result in increased use by a wider variety of wildlife species (DeGraaf et al., 1992).

FIGURE 13: NUMBER OF WILDLIFE SPECIES BY SILVICULTURAL SYSTEM AND COVER-TYPE GROUP



Total number of amphibians, reptiles, birds and mammals using each cover type taken from DeGraaf, et al., 1992.
Even-aged: forests containing regeneration, sapling-pole, saw timber, and large saw timber stands in distance units of 5 acres or larger.
Uneven-aged: essentially continuous forest canopies and intermixed size and age classes produced by single-tree selection.

7.5.2 Early-successional Forested Habitat Management

Even-aged management techniques are used to create early-successional forested habitats. Even-aged techniques used on Division lands are done on stands where some regeneration is in place. Except for plantation removals, complete overstory removals greater than two acres in size are not practiced on Division land on the Ware River watershed. In larger cuts, typically 10-20% of the overstory is retained in clusters of 5-10 trees, with an average of 2-3 clusters per acre. These occasional clumps of trees are an attempt to mimic natural disturbances. Major catastrophic events typically don't completely remove the overstory in a given area, but instead create a patchy effect on the landscape as some trees survive the event. In addition, preserving clumps of trees allows the Division to selectively save valuable mast, den, and nest trees.

In order to create conditions favorable for some early-successional species, forest openings need to be large enough and placed appropriately to provide enough habitat to sustain viable animal populations over time. It would be counter-productive to create early-successional habitat that was too small and isolated, preventing dispersal of the attracted species. As discussed in Section 5.10, forest management in Strategy Three areas will utilize even-aged management techniques to create openings up to ten acres in size, with retained structure in clumps of trees, as described above. Approximately thirty acres per year will be treated under this strategy, providing valuable early-successional forested habitat, while the vast majority of harvesting will follow uneven-aged methods. Topography, distance to tributaries, soils, stand health, and distance to human interface will be considered when planning limited even-aged management. The limited application of even-aged techniques provides opportunities to compare the effects of these larger openings on water supply protection to those of the more generally-applied uneven-aged management.

7.5.3 Early-successional Non-Forested Habitat Management Practices

7.5.3.1 Field Prioritization

The Division owns a variety of open lands. In most cases, these are either open lands the Division recently acquired through its land acquisition program or has traditionally managed in an open condition. To address the concern regarding declining field habitats, the Division will consider maintaining existing fields where doing so does not compromise water supply protection. Fields will be prioritized based on their size, distance to flowing water, relative isolation, and juxtaposition with other open fields. In general, very small (<2 acres), isolated fields will be abandoned and allowed to naturally regenerate to forest cover. In addition, those fields (or portions of fields) that border reservoir tributaries will also be abandoned and allowed to return to forest cover. This will provide an adequate forest buffer around flowing streams. Larger fields (>5 acres) that are isolated and not located near tributaries or otherwise critical to water supply protection will be maintained in their open condition through various management practices. Large (>20 acres) fields situated near (< 1 mile) or next to other fields and well-buffered from tributaries will be given top management priority, because these areas offer the greatest benefit to the conservation of regional biodiversity. Large clusters of open habitat may actually act as one unit, providing habitat for species that require large tracts of open land. These areas will be maintained or enhanced using a variety of management techniques in order to optimize the available habitat.

Following prioritization, those fields not abandoned will receive management to either maintain them in open habitat or to enhance the existing conditions. Management activities will be done by Division personnel, or through service contracts. Grasslands used for hay will be managed differently than those fields were hay production is not occurring. In both cases, wildlife considerations will be incorporated into the proposed management activities.

7.5.3.2 Non-Agricultural Grasslands

Approximately 75 acres of existing fields within the Ware River watershed are not suitable for hay production. While they are not mowed for hay, these fields still require active management in order to maintain them in a grassland condition. These non-agricultural fields present opportunities to apply various management techniques to enhance the existing habitat. The following management guidelines for mowing on lands not used for hay production will be followed:

- Mowing will be limited to not more than once annually and not less than once every three years. This will inhibit woody vegetation while allowing late-blooming wildflowers to develop.
- In years when fields are mowed, mowing will occur after August 1.

- Mower height will be a minimum of 8-10 inches off the ground to avoid impacts to habitat for small mammals and ground-nesting birds.
- Adjacent fields will be managed as one unit. Multiple contiguous fields will be managed through rotational mowing to provide a diversity of grassland types.

The Division owns several large contiguous grasslands that are potential candidates for other management activities. In addition, some smaller grasslands may also be suited to disturbances other than mowing. Burning grasslands can reduce buildup of dead vegetation, prevent the spread of woody vegetation, release nutrients into the soil, and rejuvenate plant growth. Hayfields can develop a thick layer of thatch that deters some nesting grassland birds and fire is an effective way of removing this. However, burning an area can eliminate some butterflies and moths and the newly burned area may be avoided by some bird species. If and when the Division conducts fire management of fields, the following guidelines will be followed.

- Burns will be conducted in early spring (mid-March to the end of April) after snowmelt but before bird nesting. Appropriate weather conditions should be considered.
- Grasslands will be burned once every 3-4 years, and an adjacent field will be left unburned for nesting birds during the burn year. Not more than thirty percent of the habitat will be burned during any year.
- If possible, on larger grasslands, only a portion of the area will be burned in any given year. Staggering burns allows for the development and availability of a variety of habitat conditions.

The quality of Division grasslands is variable. Encroaching exotic invasive plants are invading some fields. These plants typically crowd out native species and degrade the quality of the existing habitat. Most invasive plants are extremely vigorous and hardy and can be difficult to control. In some cases, it may be necessary to actively remove and control these species in order to optimize available grassland habitat. Multiflora rose, autumn olive, honeysuckle, and buckthorns have all been found on Division grasslands. Division staff are developing a strategic plan for addressing invasive plants.

7.5.3.3 Hay Fields

There are approximately seventy-five acres of grassland within the Ware River that could produce yearly hay crops. Most of these fields are relatively small (<twenty acres) and are distributed across the watershed. On these fields, the Division will try to establish service contracts with interested farmers for the right to harvest hay. These contracts will be similar to the forestry permits already issued by the Division. The contracts may last one year or span multiple years. Successful bidders would buy the rights to harvest hay from that particular field. Contracted fields will be subject to following restrictions in order to conserve grassland nesting birds and other wildlife:

- When feasible, cut the fields only once as late as possible, preferably after August 1 and before the first frost, but at a minimum, mowing should be delayed until late June.
- If some cutting must be done prior to late June, then cutting should occur in one of the following manners:
    - Set aside 50% of the field from cutting until late June. The unrestricted half can be cut anytime. Late season second cuttings can occur on either area at the farmer’s discretion.
    - Alternatively, cut the whole field leaving uncut strips between cut areas. The uncut strips should be at least one tractor width wide. On small fields, cut from the outside in and leave the uncut half as a patch in the middle of the field.

8 Management to Protect Cultural Resources on Division Property

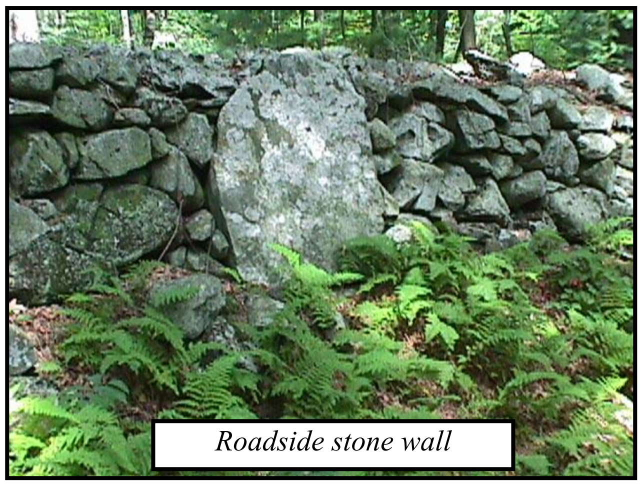
8.1 Cultural Resource Protection Goals

Cultural resources are fragile and non-renewable. Once they are destroyed they are gone forever; they cannot be restored, rebuilt, or repaired. Similar to endangered and threatened species of flora and fauna, the fragility of these resources places a value on them that is difficult to calculate. DCR/DWSP goals for protection of cultural resources are:

- IDENTIFY SIGNIFICANT CULTURAL RESOURCES ON WATERSHED LANDS.
- PREVENT DEGRADATION OF CULTURAL SITES AND RESOURCES.

Preservation legislation and DCR's Cultural Resource Management program are designed to ensure that future generations will have the opportunity to understand, appreciate, and learn about the past. The Division is concerned with locating and assessing the condition of both historic and prehistoric cultural resources, and generating plans for protecting those resources that are considered unique or are otherwise significant.

The Division's Cultural Resource Management Program at Ware River is adapted from a broader plan that was developed for the agency as a whole in 1990. The original plan was articulated in draft form by DCR Archaeologist, Thomas F. Mahlstedt in a document entitled *Cultural Resource Management Plan: Volume One, Management Policies, Operating Procedures & Organization*,. The agency plan has been modified to address the specific requirements and nature of the resources contained on the Division's watershed lands.



Roadside stone wall

8.2 Protection of Cultural Resources on the Ware River Watershed

The Ware River watershed is rich in both historic and pre-historic resources. Accordingly, safeguards have been built into the Division's land management program to protect cultural sites and artifacts, both through the identification and mitigation of possible impacts, and through a program of proactive vegetative management around significant historical sites.

8.2.1 Review of Proposed Silvicultural Projects

Without appropriate controls, forest management programs can be detrimental to archaeological resources. Modern harvesting methods employ a wide range of heavy machinery, some of which, because of weight distribution and/or tire characteristics, can do irreparable damage to prehistoric sites. Skidding logs can disturb the soil. Operations entail clearing areas for landings and access roads. Those archaeological sites that lie closest to the surface can be obliterated by such activities. Compaction or mixing of the upper layers of soils can destroy the context of shallow cultural artifacts, as well as the artifacts themselves. It is these same type of sites - those that are the youngest in time (i.e., the Early, Middle and Late Woodland archaeological periods) - that were most susceptible to destruction by the plow of the local farmer, and thus represent a relatively scarce piece of the archaeological record.

Accordingly, the foundation of the Division's Cultural Resource Management Program is a process for reviewing proposed silvicultural operations. The review involves evaluating and assessing the impacts that harvesting could have on archaeological resources if they are predicted to exist at any given operation. This process has been developed over the past several years, and is formalized in this section.

8.2.1.1 Project Description Forms

After marking the boundaries of a planned silviculture operation, Division foresters submit a *Proposed Harvesting Lot Form* to the Natural Resources section, which forwards this to the DCR archaeologist for review. The form provides a detailed narrative of the proposed operation including: location and size, description of topography, forest cover and soils, goals of silvicultural operations, equipment limitations, notable historic features, plant and wildlife communities, and hydrology.

8.2.1.2 Site Location Criteria

The primary analytical tool employed in the review of potential impacts to archaeological sites is the evaluation of site location criteria. These criteria include two distinct categories; prehistoric and historic sites.

8.2.1.2.1 Prehistoric Sites

At no time in prehistory did human populations roam haphazardly and endlessly across the landscape. Even Paleo Indians, who were the first human occupants of New England approximately 12,000 years ago, are believed to have maintained an economic subsystem that involved a seasonal pattern of restricted wandering within loosely defined territories (Snow, 1980). Over the next 10,000 years, sea levels rose and the forests and vegetative communities became more constant. During this time, Native Americans adapted their tool kit and strategies in order to take advantage of the new resource mixes and opportunities the new environmental conditions afforded. Thus, the pattern of habitat use, and consequently the locations of prehistoric sites and artifacts are largely predictable.

The key criteria for determining the archaeological sensitivity of a given site (i.e. the likelihood it was prehistorically occupied) include:

- The degree of slope (slope < 7 degrees is most sensitive).
- The presence of well-drained soils (likely encampment).
- Proximity to fresh water at the time of occupation (within 1,000 feet is most sensitive).

Other variables such as aspect, availability of stone suitable for tool-making, and elevation above sea level, may also be important. When one or more of the key criteria are met, the site of the proposed silviculture operation is considered to have been an attractive location for Native American habitation or subsistence activities, and is thus classified as *highly sensitive* or *moderately sensitive* for prehistoric resources.

8.2.1.2.2 Historic sites

In the past, Division foresters have used original land taking plans, as well as direct observation, to identify the location of historic building foundations. In 1994, the Division contracted with Boston University to inventory historic sites on its properties on the Quabbin Reservoir watershed. This inventory identified several sites that were not on the 'general taking' plans but were on 19th century town atlases. This project also improved the availability of information on the sites identified, by producing a data sheet and a map for each site. The Division hopes to continue this project in the near future in order to complete the inventory of historic sites on its properties. This information will be used when reviewing proposed silvicultural operations for their potential impacts on cultural sites.

8.2.1.3 Harvesting Restrictions and Limitations

For those silvicultural operations planned for sites that have been classified as *highly* or *moderately sensitive for prehistoric resources*, restrictions are recommended on the time of year and the types of equipment and techniques used. By employing restrictions on harvesting operations that minimize ground disturbance, a compromise is achieved that allows the harvest to occur, while affording some protection to whatever archaeological resources may lie buried below the ground.

The following are types of restrictions that may be recommended for *highly sensitive* areas.

- The harvest should occur when soil conditions are frozen or dry enough to limit soil compaction.
- Soil disturbances due to inappropriate or oversized equipment should be avoided.
- Feller-buncher-processors, with long reach and weight-distributing tracks, should be encouraged.

For those proposed operations in areas classified as *moderately sensitive,* one or more of the above restrictions may be recommended. Details of appropriate restrictions will be fine-tuned through close interactions between the Division foresters and DCR archaeologists, including analysis of past management sites for potential impacts when time and funding are available.

In some cases, particularly with large acreage sales, portions of a lot may satisfy some, or all of the site location criteria, while other portions satisfy none. In these cases, some of the above harvesting restrictions may be recommended for the sensitive portion of the operation, but not apply in other portions. On rugged upland sites with complex microtopography or significant surface stone, or in previously disturbed areas that fail to meet the key criteria, restrictions are less likely to be placed on the operations.

8.2.2 Vegetation Management at Historic Sites

Recognizing the realities of existing and likely future fiscal constraints, the Division has developed a strategy for preserving its historic resource base. The strategy is extremely modest in hours and cost, but it can have a lasting effect on the survival of historic archaeological sites.

Vegetation, if left to grow unchecked in and around stone foundations, and other historic structures like dams and raceways, will ultimately alter these archaeological features. The dislocation of foundation stones and the spalling of cement caused by root activity are among the most immediate threats to some of these cultural resources. Should uncontrolled growth continue, the existing archaeological remains may be of little value at the time that the Commonwealth is once again prepared to undertake protective management.

Accordingly, a limited and selective management program to control vegetation growth in and around archaeological sites and historic buildings and structures is recommended. This same limited program has been employed on historic sites in the DCR Reservations & Historic Sites Division.

As a general site stabilization and preservation technique, vegetation management will entail:

- Removal of most small to medium sized brush, saplings, and trees from on and within archaeological features (e.g., cellar holes and their foundation walls; mill dams; historic buildings).

- Removal shall be by cutting as close to the ground as feasible. Vegetation should not be pulled, or otherwise dislodged in a manner that would affect root systems.

- Removal, when appropriate, by a tracked feller-buncher. While manual removal may often be the best technique, in some cases where the terrain is sufficiently level and stable, a tracked feller-buncher may be appropriate. This machine has a long reach that limits the need to bring equipment too close to the structure. It severs and then picks the tree up, thus there is no concern about the direction of the fall. In addition, the tracks tend to distribute the machine's weight, thereby limiting compaction of buried artifacts.

In most cases, Division staff will perform the vegetation management around historic sites. However, there may be private loggers who are well known to Division foresters and are particularly skilled and careful, who could be allowed to undertake this work in the context of an adjacent commercial harvest. At sites that are imminently threatened, and that otherwise fall within a proposed silvicultural operation, it may be possible to allow the private logger to perform the selective cutting around historic sites. In all cases, timber harvest permits should include clauses that direct the logger to take extra care and precautions around cellar holes and foundations. Vegetation management will require periodic additional treatment depending on the nature of the growth, condition, and significance of a specific site.

8.2.3 Long Range Cultural Resource Management Initiatives

The following is a list of important initiatives that should be undertaken when funds and staffing are available:

- Inventory historic sites. Identify by age, owner, activities, and buildings. This data has been compiled for most of the Quabbin properties and has been used to help list priorities for vegetation management efforts and improve the review of silvicultural operations. Future inventories should cover the remaining Division lands, including Ware River, Wachusett, and Sudbury properties.

- Enter known prehistoric sites into the Division's GIS.

- Map sensitivity criteria for prehistoric sites using GIS.

- Conduct archaeological sampling of plantations, which were primarily planted on previously cultivated land, to determine the nature of sub-surface disturbance and survival factor for prehistoric sites.

- Develop educational signs and displays on Native American land use of the region.

- Encourage local universities to conduct archaeological field schools on watershed lands to further test and refine site location criteria.

9 Research, Inventory, and Monitoring Needs

A variety of watershed research projects are conducted on Division properties by outside agencies and institutions. The Division supports these projects through access to its properties and, occasionally, limited support in the form of funding and/or Division staff time. This research has informed Division managers and has improved or supported watershed management practices.

Listed below is a variety of current research, inventory, or monitoring needs on Division properties on the Ware River, in the general areas of forestry, wildlife, and cultural resources. These are listed in part to direct the Division's own research and monitoring efforts in the coming decade, but also as a specific reference for potential researchers who are looking for a project that would address a real need of the Division.

9.1 Forest Research Needs

9.1.1 Monitoring of Forest Management Activities

The DCR/DWSP policy to allow no measurable impact upon stream water quality from forest management activities creates a need to establish a standard approach to measuring compliance. Streams should be monitored to correlate short-term water quality changes and active logging conducted on Division lands within DCR/DWSP standards. Monitoring should involve upstream and downstream and/or paired watershed sampling before planned operations, during active logging, and following the completion of the operations. The study should include storm event testing. Parameters should include pH, temperature, dissolved oxygen, turbidity, suspended solids, total particulates, total and fecal coliform, and nutrients. Based on this fieldwork, specific recommendations could be made outlining a low cost, statistically valid method of monitoring logging operations on a more wide-scale basis. Recommendations for adjustments in current Division Conservation Management Practices would be made, if necessary, based on this research.

9.1.2 Invasive Plant Species

A wide variety of invasive plant species is currently established on and adjacent to Division properties on the Ware River watershed. Control of these species is important to the establishment of tree regeneration and the maintenance of native plant diversity. To begin to address this issue, a survey of invasive plant species on the watershed and the extent of their spread should be conducted and added to the Division GIS, in part to establish an historical reference point for future distribution of these species. Once priorities have been established for control, further research needs to be conducted on the feasibility of mechanical controls and/or the relative benefits and threats associated with chemical or biological controls.

9.1.3 Evaluation of Ware River Access Roads

This project would include a watershed-wide mapping of road conditions to be used as a management tool in maintaining and improving the current road network. Part of this project would involve locating the most appropriate model for sizing culverts, and utilizing GIS to routinely size culverts and design drainage characteristics to withstand 50-year storms. The results of this study would also be useful in planning road repair, maintenance, or construction on newly acquired property.

9.1.4 GIS Projects

There is great potential for increased use of GIS technologies in the management of the natural resources of the Ware River watershed. Essentially every component of the Division's management efforts could utilize the analytical and mapping capabilities of this technology. There is a need to either establish contracts to generate GIS data, or to increase the capabilities of the current DWSP in-house GIS capability. Examples of potential GIS projects include mapping stone walls and cultural resource locations on Division property, and incorporating rare plant and animal locations in review maps for proposed timber harvesting.

9.1.5 Hemlock Woolly Adelgid Impact Monitoring

The invasion of the hemlock woolly adelgid into Division watershed forests at Wachusett and Quabbin Reservoirs has generated wide-ranging discussion regarding the future of Eastern Hemlock throughout the region, and the potential impacts to water quality and the forest ecosystem resulting from its decline. A long-term study is needed to track the extent of the invasion and infestation and monitor the impacts with an emphasis on water quality. This study could also monitor the effects of the salvaging of dead and dying hemlock and therefore help inform future management decisions.

9.2 Wildlife Research Needs

Although limited wildlife research or monitoring has been conducted on the Ware River watershed in recent years, some monitoring of high priority species has occurred. More work is needed. The following projects represent a few areas where technical data would assist in managing Ware River wildlife resources more effectively.

9.2.1 Dynamics of Ware River Beaver Populations Where Trapping is Restricted

Beaver are considered a high priority species. Division regulations allow trapping at the Ware River, and trapping occurred regularly in the past. However, since the passing in 1996 of a referendum limiting trapping, there has effectively been no trapping mortality on beaver in the Ware River watershed. Even if the law were modified, there are very few trappers left in the state to resume the activity. As a result, beaver populations in the Ware River have expanded. By determining the population dynamics and dispersal of beaver in the watershed, we can gain better understanding of habitat use, natural mortality, and the importance of marginal habitat.

9.2.2 Biological Surveys and Inventories

In order to minimize or avoid negative impacts of land management activities on wildlife and critical habitats, all proposed activities are reviewed by Division wildlife biologists. However, current staffing is limited, and it would be impossible to carefully inspect each of the hundreds of acres affected by proposed management activities. The Division must rely on foresters and others working in the field to add their observations to existing records of known occurrences of critical habitat or species. Although new information is added as it becomes available, the database is far from complete. Biological surveys conducted by qualified persons can provide critical additional information that will aid Division efforts to protect these resources during land management activities. Information should also be incorporated into GIS datalayers.

9.2.3 Vernal Pool Surveys

The Division recently completed a contract that mapped potential vernal pools on the watersheds using color infrared photos. Over 300 potential pools were identified. These pools are gradually being surveyed by Division staff to determine their importance as habitat and to try to locate other unmapped pools. To improve protection for this resource, the survey and mapping effort should be increased. The mapping will be incorporated into GIS to facilitate land management planning.

9.2.4 Dynamics of the Expanding Ware River Moose Population

Moose populations continue to expand at the Ware River. Division land within the watershed appear to serve as a corridor and core habitat for the species within the state. Little research has focused on moose populations in the southern extent of their range. Research would focus on the habitat use and population dynamics of moose and the potential impact of an increasing moose population on forest growth and regeneration.

9.3 Cultural Resources Research Needs

The principal research need for the continued protection of cultural resources within Division properties on the Ware River watershed is to inventory, accurately map, and digitize all known historic cultural sites. This inventory would be modeled after the multi-phased historic site inventory that was completed for the Quabbin Reservoir watershed in 1995-96. The Quabbin inventory was completed by graduate students and faculty of the Boston University Department of Archaeology in collaboration with the DCR/DWSP staff archaeologist. The process involved integration of location and descriptive information from a variety of cartographic and historical resources, including MDC Real Estate Plans and a series of maps dating as far back as 1794. Information from these sources was used to complete a database and map record for several hundred sites. Many of these sites were subsequently field checked for current condition. Spatial information is entered in the Division's GIS database so that important sites can be identified when management activities are proposed for areas within Division properties. This process greatly enhances the ability of managers to protect historic cultural resources.

10 Appendix I: Discussion of Forest Management Approaches

The Division has an obligation to select a resource management approach that clearly meets our principal mandate for water supply protection and, where compatible, to choose one that meets other directives as well. In designing the approach for Division properties on the Ware River watershed, the benefits and limitations of three broad approaches were considered: naturally-managed forests, even-aged management, and uneven-aged management. Each approach is summarized below in general terms. The literature review and analysis below then considers the effects of each approach on water yield and water quality, as well as broad potential effects on secondary objectives such as wildlife habitat and aesthetics.

10.1 Naturally-managed Forests

10.1.1 Description

Natural management refers to forests, or areas within forests, in which deliberate, direct human manipulation does not occur. No forest on earth is without human impact, given that human activities affect climate, the distribution of insects and diseases, and the quality of air and precipitation throughout the globe. In the context of this plan, however, natural management refers to areas in which trees are not deliberately cut or harvested, and where changes in the forest are primarily the result of natural disturbances such as catastrophic wind, snow and ice, or autogenic processes of aging and decay. Attiwill (1994) provides an excellent review of the literature on natural disturbances in forests.

10.1.1.1 Water Yields

Tree growth and naturally occurring forest disturbances (fires, wind, disease, and insects) heavily influence the water yields from naturally-managed forests. Eschner and Satterlund (1965) studied a 491 square-mile watershed in the Adirondack Mountains of New York from 1912-1962. This study is particularly relevant to an examination of the impact of naturally-managed forests upon water yields. Land use on the watershed up to 1910 included land clearings, extensive fires, and heavy forest cuttings (chiefly logging of softwoods). In the late 1800s, the state of New York began purchasing lands in the watershed for the Adirondack Forest Preserve. From 1890 to 1910 the percentage of state-owned Forest Preserve in the watershed increased from 16% to 73%. The management policies of the Forest Preserve included laws against any cutting of trees and an active program of forest fire suppression.

The average forest density (in basal area) of the watershed increased from 65 square feet per acre in 1912 to 107 square feet per acre in 1952, due to forest growth and restrictions on cutting. Average basal area decreased to 97 square feet per acre in 1963 due in part to mortality from a windstorm in 1950. There was also a large increase in the beaver population during the study period. Throughout the Adirondacks, the number of beaver increased from an estimated 10 individuals in 1895 to an estimated 20,000 individuals by 1914, due to a prohibition on trapping introduced in 1895 and the introduction of 25 Canadian beaver and 14 Yellowstone Park beaver between 1901 and 1907. In 1965, most perennial drainages in the watershed were occupied by beaver.

The combined effects of unregulated forest growth and the increased number of beaver dams reduced the annual water yield of the watershed by 7.72 area-inches, or 23%, from 1912 to 1950. Eschner and Satterlund (1965) postulated that forest growth reduced water yields through changes in evapotranspiration and snowmelt and beaver reduced yields through evaporation losses from beaver ponds. Although the net effect from beaver was a reduction in water yield, dormant season flow increased due to reduced interception and evapotranspiration following the killing of trees in flooded areas. The general effect of unregulated forest growth in lowering water yields was offset to some extent by increases in water yields resulting from the paving, straightening, and widening of seventy-five miles of roads within the watershed during the study period.

The trend of decreased water yields from 1912-1950 was reversed due to the large number of trees that were killed by a severe storm that occurred on November 25 and 26, 1950, and the continued increase in mortality during the 13 years after the storm. According to Eschner and Satterlund (1965):

> The storm of November 1950, disrupted the associated patterns of forest stand development and streamflow change, returning both to a point nearer their 1912 levels.

In a separate study, Eschner (1978) analyzed four small watersheds in the Adirondack Mountains of New York. Logging, farming, and fires up to the early 1900s heavily impacted the East Branch of the Ausable River. Of the four watersheds, only the East Branch of the Ausable River was unaffected by the windstorm of 1950. This watershed offers a good example of a 42 year, stream-gauged period of uninterrupted forest re-growth. During this period, streamflow decreased by 4.2 area inches. Eschner concluded that this decrease was due to the natural regrowth of vegetation.

10.1.1.2 Water Quality

The impact of disturbance is perhaps the key difference between a naturally-managed and actively-managed forest. In the actively-managed forest, silvicultural management is in effect a deliberate and regulated form of disturbance. In the naturally-managed forest, most disturbances are the result of unregulated natural events (e.g., wind, fire, disease, insects, or ice). While harvesting may at times concentrate on the same species affected by natural disturbances, harvesting extent is either regulated or practically restricted, while natural disturbances are not deterred by steep or wet areas. While both actively-managed and naturally-managed forests will be exposed to certain recurring natural disturbances (e.g., hurricanes), the two systems may respond to these disturbances very differently.

In recent years, even forests isolated from developed areas are being increasingly impacted by human factors (air pollution, introduced insect/disease complexes). Eschner and Mader (1975) note:

> When extensive areas of relatively stable vegetation are set aside for wilderness, man's activities are sharply restricted. However, changes in the vegetation continue, and in some cases the possibility of catastrophic change increases...Treatment of large areas of watershed as wilderness, currently advocated by several interest groups, may not be consonant with management for maximum yields or protection of areas. On land long undisturbed, use of water by vegetation may be maximized and water yield reduced, while hazards of windthrow, insect, disease, or fire damage may increase.

Hewlett and Nutter (1969), in defining pollution, mention the potential impact of natural disturbances upon water quality:

> Because natural waters already carry materials that can degrade water for certain uses, we have some difficulty specifying just what "pollution" is. Natural water quality over the centuries has evolved the stream ecosystem under conditions that we might, rather pointlessly, refer to as "natural pollution." For our purposes, however, we shall regard pollution as man-caused and think of polluted waters as those degraded below the natural level by some activity of man. In this sense, therefore, unabused forests and wildlands do not produce polluted waters, although they may at times produce water of impaired quality.

Parsons et al. (1994), in a study of the impact of gap size on extractable soil nitrate stated:

> Large-scale mortality events leading to macroscale gap formation, which involves the simultaneous death of many adjacent trees over thousands or tens of thousands of square meters, are known to increase mineralization and nitrification rates in temperate forest ecosystems.

Tamm (1991), in reviewing the role of nitrogen in terrestrial ecosystems, noted:

> Natural agents such as storms, insect defoliations, and, above all, fire may destroy the existing vegetation and stimulate both nitrogen mineralization and nitrification, leading to temporary losses of nitrate.

Corbett and Spencer (1975) report that Hurricane Agnes and the 14 inches of rain that accompanied it caused significant erosion impacts on the Baltimore municipal watershed, chiefly due to streambank cutting and channel slumping. The authors note that these types of impacts are more related to channel depth than condition of forest cover. Hurricane Hugo caused extensive damage to coastal South Carolina. The U.S.D.A. Southeast Forest Experiment Station monitored stream waters within the Frances Marion National Forest before and after the hurricane, with a gap in monitoring for several months after the hurricane, due to access problems (McKee, 1993). The forest before the storm was mature pine-hardwoods and much of it was windthrown or snapped by the storm. Preliminary results showed increased nitrogen in streams compared with levels found in regular monitoring done before the storm. Mineralization in areas of high tree mortality, with limited soil nitrogen uptake, can raise the potential for excess mobile nitrogen that may make it to streams (Gresham, 1996). These and many other effects of Hurricane Hugo are summarized by the USDA Forest Service (Haymond and Harms, 1996).

Researchers in South Carolina are also concerned about the threat of a large forest fire due to the amount of downed material, which has increased from 8 tons/acre before the storm to 100 tons/acre after the storm. After a 1.6 acre simulated hurricane "pulldown" at the Harvard Forest, Carlson (1994) reported that downed woody debris increased from 4.1 tons/hectare in a control area to 33.5 tons/hectare. He suggests that the potential threat of fire will increase in the next several years as pulled-over trees die.

Numerous studies show that impacts from forest blowdown or a combination of blowdown and forest fire can increase tributary nitrate and phosphorus exports by several times background levels (Verry 1986 and Packer 1967 as cited in Ottenheimer 1992; McColl and Grigal 1975; Wright 1976; Schindler, et al., 1980). Soil disturbance from blowdown of large numbers of trees may also result in significant erosion (Patric, et al., 1984; White, et al., 1980). Water quality changes associated with extensive windthrow and fire confirm that dissolved nutrients and in some cases, sediment, acidity, and total organic carbon can be elevated for several years (Patric 1984; Verry 1986; Schindler, et al., 1980; Wright 1976; Corbett and Spencer 1975; McColl and Grigal 1975; Dobson, et al., 1990; Dyrness 1965 and McKee 1993). For example, nitrates increased by up to nine times and phosphorus by more than three times after extensive windthrow followed the next year by a wildfire in a monitored watershed in Ontario (Schindler, et al., 1980).

Dobson, et al., (1990), reviewing data from hundreds of lakes in New York, New Hampshire and Sweden, found strong spatial and temporal associations between percentage of watersheds affected by large blowdown events and long-term lowered pH in basin lakes. They concluded that extensive blowdown alters hydrologic pathways by channeling flow through large macropores created by rotting roots so that water is less buffered by subsurface soils and bedrock. One lake adjacent to heavy blowdown that was extensively salvaged did not acidify, leading the authors to speculate that salvage may partially counter the impacts of blowdown on acidification.

The value of advance regeneration (regeneration established before overstory removal) in reducing the impacts of natural disturbances may be the critical factor distinguishing actively managed and naturally managed watersheds. After disturbance, areas that are quickly occupied with dense, fast-growing seedling/sapling growth should minimize transitional losses of nutrients, and particulate and erosion losses. Buzzell (1991) and Kyker-Snowman (1989) compared actively managed and naturally managed forests on DCR/DWSP watersheds with regard to the presence and abundance of advance regeneration. Their findings demonstrate that active management can maintain consistently higher levels and spatial distribution of regeneration and young forest growth than those produced in unmanaged areas. Arbogast (1957) notes that a key consideration for implementing uneven-aged silviculture on previously unmanaged and undisturbed stands is to enhance age-class balance by encouraging otherwise unpredictable development of sapling and pole-sized trees.

The impact of actively managed and naturally managed forests adjacent to stream channels is discussed thoroughly in Maser et al. (1988). Although this study is focused on forests of the Pacific Northwest, some principles are applicable to the northeast. The authors documented that streams flowing through young forests and those recently harvested contain only 5-20% of the large woody material found in streams flowing through naturally managed forests. The stability and length of wood pieces is also increased in naturally managed forests. While the authors document a clear difference in the fish habitat of the two streams, they also note that the increased debris in streams bounded by naturally managed forests may impact the stability of streams.

While it may seem that large amounts of woody debris would increase the amount of decomposed organic material in streams, wood in direct contact with water decomposes very slowly. Maser et al. (1988) note that only 5-10% of a stream's nitrogen supply is derived from rotting instream debris. On the positive side, debris serves to create hundreds of dams that slow the flow of particulate material down the stream. The authors speculate that stream stabilization after floods is accelerated by large woody debris, noting that “large stable tree stems lying along contours reduce erosion by forming a barrier to downhill soil movement.”

While the forest conditions in the Pacific Northwest are very different from those in the northeast (for example soils in the northwest are less stable, forest types are different, and even-aged management using clear-cutting is the most common silvicultural approach), some of the above material has been verified in the northeast. Bormann et al (1969), in a study of a small watershed in the White Mountains of New Hampshire, noted that 1.4% of the watershed was included in the actual stream channel and that debris pools occurred every 1-3 meters. They speculated that these pools served to slow the movement of suspended material from the watershed and reduce the erodibility of the system. Bormann et al. (1974) note that in mature forests the export of particulate material is derived from material stored in the stream bed. However, they note that most of this material moves very little, and approximately 90% decomposes slowly in place.

The above discussion highlights the need for careful consideration of lands adjacent to tributaries. In developing management plans for these areas, consideration should be given to the need for stability of the cover type and forest structure, given the potential occurrence of major disturbances. However, the benefits of the slow addition of natural wood-fall to these areas, and the erosion impediments and the stream pools created by this material, should also be considered. In assessing the management of stream buffers, Stone (1973) recommends careful thinning of buffer strips as often preferable to complete non-disturbance, as such thinning will limit the amount of debris falling directly into streams. Vellidis (1994) found that forested riparian strips next to agricultural lands took up and removed nutrients in soil and vegetation, preventing agricultural outputs from reaching streams. The author recommends that these forested strips be harvested periodically, if they are to serve as an effective nutrient buffer, to ensure a net active uptake of nutrients.

10.2 Even-Aged Silviculture

10.2.1 Water Yields

Beginning at Wagon Wheel Gap in Colorado in 1911, experiments relating forest removals to water yield increases have been conducted at a number of small watershed locations throughout the U.S. Since 1940, three U.S. Forest Service Experimental Forests have supplied the bulk of the data for eastern U.S. applications. These forests are Hubbard Brook, NH; Fernow, WV; and Coweeta, NC. Experiments have included a wide variety of approaches ranging from clearing of small watersheds to patch, partial, and riparian cuts. Most experiments are paired watershed studies, where two small, adjacent or similar watersheds are studied; one watershed is treated silviculturally while the other is left uncut, as a control.

Experimental findings show several general trends. However, variation due to site conditions such as slope, aspect, soils, geology, cover type, and additional factors make exact prediction of water yield increases difficult for a given site. Douglas (1983) notes that yield increases can be predicted within 14% of actual values. Federer and Lash (1978) developed a small watershed computer model aimed specifically at predicting water yield increases from forest management of small watersheds in the northeast, using input variables of precipitation, temperature, latitude, slope, aspect, cover type, and soils.

The following general trends emerge from the many watershed experiments that have been reviewed for Division Land Management Plans:

- Water yields increase as the percentage of forest cover removed increases. Complete removal of hardwood cover on small watersheds can result in first-year yield increases of 4-14 area-inches (total average annual streamflow in the Northeast is approximately 20-25 area-inches or about 50% of total precipitation).
- Water yields decrease with reforestation of open watersheds and growth of younger forests. There is a linear relationship between the percentages of watershed reforested and water yield decrease. Yield decreases are significant, in the range of 6-7 area-inches lost through significant forest growth/regrowth.
- Water yield increases are greatest the first year after cutting and decline thereafter, usually returning to pre-cutting levels by the fourth to eighth year. Yields on most clearing experiments returned to pre-cut levels within 10 years.
- Water yield increases are generally larger on north versus south facing slopes, with yields up to two and one half times greater for clearings on north facing slopes. One study also showed that west-facing forests used more water than those on east-facing slopes.
- Differences between cut and uncut watershed yields increase exponentially as annual rainfall increases.
- Water yield increases from cutting occurred primarily during the growing season in the many studies in the northeast. Areas of higher snowfall, deep soils, or conifer cover showed larger dormant season increases.
- Removal of conifer forests will yield more water than hardwood forests. Conifers use more water annually and snow interception and evaporation is greater in conifers.

- Conversion of hardwoods to conifers will result in significant losses in water yields. A 25% yield loss was measured on a North Carolina watershed after conversion of hardwoods to white pines.
- Greatest yields are usually achieved through removal of riparian vegetation or lower elevation watershed vegetation.
- Much of the increased flow generated from cutting is seen as increases during low flow periods.
- Increases in peak flows do occur, but are not believed to cause increased flood risk where cutting is implemented on limited areas, resulting in moderate yield increases overall.
- Watersheds with deep soils generate longer lasting yield increases after cutting, and yields are more balanced between growing and dormant seasons. Watersheds with shallow soils generate yield increases focused within the growing season.
- Certain early successional hardwoods use measurably more water than late successional hardwoods. Changes in water yield due to shifts in species composition may last in excess of a decade.
- Yield increases are lower in deep soils and in areas with a rapid regeneration response.

(Douglass and Swank 1972, 1975; Douglass 1983; Hibbert 1967; Federer and Lash 1978; Hornbeck and Federer 1975; Hornbeck et al., 1993; Lull and Reinhart 1967; Mader et al., 1972; More and Soper 1990; Mrazik et al., 1980; Storey and Reigner 1970; Trimble et al., 1974.)

Douglass (1983) and Storey and Reigner (1970) emphasize the significance of the above findings as a way to help meet present and future water supply needs in the eastern United States. In general, it seems evident that even-aged management techniques, especially using clear cutting in large blocks, will have the most dramatic effect on water yields.

While clear cutting of entire reservoir watersheds is not reasonable given water quality concerns (see next section on water quality), judicious rotation of clear cuts may provide significant flow increases, especially during the growing season when improved yields are most needed by water supply managers. A compelling argument has been made that the major difference between even-aged and uneven-aged silviculture is the extent of edges and edge effects that remain following the cutting (Bradshaw, 1992). Streamflow response to logging is proportional to the relative amount of edge created by the timber removal, so that greater relative edge results in less streamflow response, and large clearcuts, with a relatively low edge to opening ratio, produce the greatest streamflow response (Satterlund and Adams, 1992, p. 281).

Douglas and Swank (1972) summarize the value of forestry for water supply managers:

> We can conclude from the experimental watershed evidence in the Appalachian Highlands that cutting forest vegetation has a favorable impact on the water resource by supplementing the supply of fresh water when consumptive demands are most critical. And, the amount of extra water produced can be predicted with a degree of accuracy that is sufficient for many purposes. Although heavy forest cuttings will usually increase some stormflow characteristics on that portion of the watershed cut over, regulated cutting on upstream forest land will not produce serious flood problems downstream.

10.2.2 Water Quality

In describing the influence of even-aged and uneven-aged management upon water quality, most studies reviewed involved either clear cutting (of whole watersheds or in limited blocks or strips - all of which fall under even-aged management) or partial cutting (where part of or most of the overstory is retained). The shelterwood regeneration system is a form of even-aged management involving removal of the forest overstory in stages, generally within 10-30 years. While the cuttings in this system appear initially as partial cuttings, they ultimately require the removal of all or most of the overstory in order to bring about the desired regeneration.

The impacts of even-aged management systems upon water quality vary with intensity and location of management; intensity, layout and maintenance of road systems; and planning and supervision of logging and woods roads operations (Lull and Reinhart 1967; Kochenderfer and Aubertin 1975; Hornbeck and Federer 1975). The water quality parameters principally affected by these activities are turbidity, nutrient levels, and stream temperature.

10.2.2.1 Turbidity

Turbidity is affected by soil exposed in poorly planned, located, and maintained road systems and log landings (Kochenderfer and Aubertin, 1975). For example, gravel access roads may have an infiltration capacity of 0.5 inches per hour, while forests have capacities up to 50 inches per hour (Patric 1977, 1978). Haphazardly built road systems may utilize 20% of a watershed, while well planned road systems may utilize 10% (Lull and Reinhart 1967). In addition to access and skid roads, the total compacted area of a typical logging area including landings may approach 40% (Lull and Reinhart, 1972). MDC/DWM conducted a study in 1986 of pine thinning on the Wachusett Reservoir watershed completed by Division watershed crewmembers and two private loggers under Division supervision. For this study, the total area impacted by logging - including access roads, skid roads, and landings - ranged from 14.8% (Division crew) to 19.6% (private loggers) (Kyker-Snowman 1989b). Stone (1973) reported soil disturbances covering 15.5% of the logged area for selection cutting, versus 29.4% for clear cutting in eastern Washington. Sediment export was directly proportional to the percentage of a watershed in roads and reducing this percentage was seen as critical for reducing sediment in streams in the Pacific Northwest (Dyrness, 1965).

Hornbeck, et al., (1986) report that increases in soil disturbance means greater erosion. Martin (1988) recommends setting predetermined travel routes for equipment and doing winter logging and using tracked vehicles rather than wheeled vehicles in sensitive areas. Hewlett (1978) recommends avoiding locating roads near perennial and intermittent stream channels in order to eliminate impacts.

A study of erosion on New York City's water supply watersheds highlighted the importance of protecting road and stream banks from the effects of erosion (S.U.N.Y., 1981). This study of the erosion sources at the Schoharie Reservoir estimated that while road banks made up only 0.22% of the watershed, they were the source of 11% of all erosion. Streambanks, which made up only 0.44% of the watershed, were the source of 21% of all erosion.

Gravel access roads generally represent the only areas of exposed soil on forested watersheds. As such, they are the greatest potential non-channel source of sediment (Satterlund and Adams, 1992). Proper maintenance is required to eliminate the potential adverse impacts on water quality. The rainfall erosion index (EI) of a storm is its total kinetic energy times its maximum 30 minute intensity

(Wischmeier and Smith, 1965). For the New England region, the average annual EI value is between 100 and 150. These values vary with soil type, but with gravel roads they are fairly consistent.

The greatest force exerted by water is generally the impact of raindrops when they hit. On forested watersheds this impact is mitigated by litter cover (Satterlund and Adams, 1992). On non vegetated road surfaces rainfall can detach and move soil particles. On level soils there is no net soil movement, and thus no net erosion, unless overland flow occurs (Satterlund and Adams, 1992). Overland flow from roads starts as rill erosion (small riverlets) that moves down slope. As these coalesce they form channels that increase in volume and erosive force. Erosive force of moving water is directly proportional to its mass (volume) and velocity (Brooks et al., 1992). The velocity and volume of water is affected by increases in slope and length of slope.

Measures that reduce the volume of water carried and the velocity at which it moves will reduce its erosive force. The prompt removal of water from road surfaces reduces velocity and volume by reducing the duration of contact with exposed surfaces and by shortening slope distance. These are accomplished by maintaining a proper crown of the road surface, by ditching the road edges and by maintaining release ditches to carry water away from the road. Crowned roads give the greatest control over water. Grading reshapes the road surface removing ruts and holes providing a smooth crown so water moves laterally into side ditches off the exposed surface.

Slope and the type of road material also affect the potential erosion risk for access roads (Satterlund and Adams, 1992). As slopes increase water velocity increases as does the erosive force of a given volume of water. Road materials vary in their ability to resist the force of detachment and movement. Particle size and compactability determine a material’s resistance to erosion. As particle size increases the force required to dislodge and to move them increases. The attraction between particles acts to increase the force required to detach particles, decreasing the risk of erosion. Vegetation increases resistance to the erosive force of moving water by helping to bind soil particles into conglomerates and by decreasing the velocity of water (Brooks, et al., 1992). Construction of new access roads carries the greatest risk of erosion. Stone (1973) notes that some turbidity is inevitable with construction and initial use of new roads, but that almost all continuing damage from roads is avoidable by using recommended woods roads maintenance techniques.

A comparison study of graveled and ungraveled forest access roads in West Virginia showed that the application of even 3 inches of gravel reduced sediment losses eight-fold, even though the gravel road carried two times the traffic of the ungraveled road (Kochenderfer and Helvey 1974).

Lynch et al. (1975) traced increased turbidity on watersheds in Pennsylvania to scarified log landing areas. However, Kochenderfer and Aubertin (1975) report that:

> Bare soil exposed by road building, and to a much lesser extent by log landings, has long been recognized as the major source of stream sediment associated with logging operations.

Turbidity in a West Virginia watershed that was clearcut was traced to both road erosion and channel scour from heavier overland flow (Patric 1976). Channel scour is an impact that is unique to large-scale disturbances where peak flows may increase.

Mechanical compaction of soil reduces soil infiltration and reduces tree seedling survival (Martin 1988). Erosion problems result when mineral soil is exposed to rain, especially on areas with long, steep slopes. However, even compacted, exposed soils have high infiltration capacities. The most significant erosion occurs when soil is bared to the “B” horizon, beneath the organic and leached horizons (Patric 1977).

Division staff measured soil bulk density (a parameter which shows soil compaction) on transects through a pine thinning at Wachusett Reservoir with three types of conventional logging equipment. Average soil bulk densities did not change significantly when measured before and after logging done by the Division's crew with a conventional small skidder and a forwarder. Average bulk density before logging was 6.18 grams/cubic centimeter (gms/cm) and 6.21 after logging; 13 gms/cm is considered the level where root penetration is inhibited. Stone (1973) reported that soil compaction varies enormously with soil type, moisture content, frequency of traffic, and type of “packing” impact. He concluded that the key to avoiding erosion from logging is to ensure that protection steps will handle extreme rain events on the most sensitive sites. The careful planning of skid roads is essential.

Cuttings where soils are not disturbed by roads or skidding do not discernibly increase turbidity (Kochenderfer and Aubertin, 1975; Dyrness 1965; Bormann et al., 1974). In Connecticut, 80 logging locations were checked for compaction, erosion, and stream sedimentation. All such problems were found to be related to the transportation aspects of logging (O’Haryre 1980, as cited in More and Soper 1990). Other studies trace turbidity to erosion from heavily used logging roads, particularly after heavy rainstorms and from increased streamflow that caused channel erosion (Patric 1976; Pierce, et al., 1970 as cited in More and Soper, 1990).

Turbidity measurements were compared on watersheds in the Fernow Experimental Forest, West Virginia; treatments included a commercial clearcut, a silvicultural clearcut, and one watershed with no cutting. Turbidity (in Jackson Turbidity Units – JTU, a precursor to the current Nephelometric Turbidity Units - NTU) during logging was 490, 6, and 2 units respectively. One year after cutting, turbidity was 38, 5, and 2 units respectively (Kochenderfer and Aubertin, 1975). Douglass and Swank (1975) concluded that well-planned, well-maintained road systems do not damage water resources. In a comparison of logging with planned and unplanned skid trails, the planned logging had turbidity of 25 JTU while the unplanned logging had 56,000 JTU (Reinhart and Eschner, 1962, as cited in Brown 1976). A comparison of regulated and unregulated logging in 1947-48 found that unregulated logging increased turbidity 10-20 times background levels while regulated logging increased turbidity only slightly (Douglass and Swank, 1975).

In a study at Hubbard Brook, New Hampshire, a watershed was logged with a strip cut even-aged method. In the two years during and after logging, 6 of 147 streamwater samples exceeded 10 turbidity units (Hornbeck and Federer, 1975). A study of different stream crossing techniques on Division properties in the Ware River watershed found that temporary bridge crossings caused less impact than ford crossings or crossing on poles. Increases in turbidity caused by temporary bridge crossings were not measurable beyond 100 feet downstream from the bridge (Thompson and Kyker-Snowman, 1989).

Clearing of riparian areas has been associated with increased turbidity (Corbett and Spencer, 1975). Lynch, et al. (1975) compared middle slope clear cuts with lower slope clear cuts and found turbidities of 4 part per million (ppm) on middle slope cutting, 196 ppm on lower slopes, and 2 ppm on an uncut control watershed.

While useful predictive models exist to estimate soil loss from agricultural practices, few soil loss predictive models exist for silvicultural operations. Burns and Hewlett (1983) developed a model that evaluated clearcut, disking, and planting operations in the southeastern U.S. This model is based on the percentage of bare soil after logging practices and the location of bare soil areas with regard to perennial stream channels. The authors recommend keeping any exposed soil areas away from wet and dry stream channels, in order to minimize erosion. Currier, et al. (1979) developed a procedure for analyzing water quality impacts from forest management. Larson, et al. (1979) began assembling existing data into a system of computer models. Li, et al. (1979) developed a sediment yield model based on the Universal Soil Loss Equation and tested in Colorado.

10.2.2.2 Nutrients

Logging impacts on nutrient levels can vary by the amount of cover removed, type of cover removed, watershed slope, location within the watershed (lower areas cause faster nutrient input, but higher areas can cause greater nutrient loss), and the timing of the regeneration response. Soil type and depth also control impacts (e.g., deep, poorly-drained, fine-textured soils tend to bind free nutrients before they reach streams) (Bormann, et al., 1968; Brown 1976; Carlton 1990; Martin and Pierce, 1980; Martin et al., 1984). While turbidity increases are caused by soil disturbance, increases in nutrient levels can result solely from cover removal. For example, at Hubbard Brook, New Hampshire, when all trees on a catchment were cut and left on the ground and herbicides applied to prevent regrowth, stream concentrations of several ions increased significantly (Douglass and Swank 1972). In this study, nitrates increased more than forty times background amounts, and exceeded modern drinking water standards (Bormann et al., 1968). Cuttings associated with significant nutrient increases typically involve clearing of large percentages of watersheds. However, even clearing of entire watersheds at Fernow Experimental Forest, WV and Pennsylvania State Experimental Watersheds did not appreciably increase nitrates (Kochenderfer and Aubertin 1975; Lynch et al., 1975), so site conditions are critical to comparisions.

Nutrient increases from cleared areas are derived both from the increases of nutrients released as the decomposition process increases in sunlight and by the reduction in uptake due to the loss of plant cover (Vitousek 1985). At Hubbard Brook, New Hampshire, strip clear-cutting of one third of a watershed caused nitrate increases of nearly two times an undisturbed watershed and one third that caused by a watershed that was completely clear-cut (Hornbeck, et al., 1975). The coarse-textured soils of New England that have lower nutrient-holding ability may be more susceptible to nutrient losses, particularly in areas without plant cover (Hornbeck and Federer, 1975). Soils that are shallow to bedrock, thin unincorporated humus on infertile soil, and coarse skeletal soil on steep slopes are particularly susceptible to nutrient loss (Williams and Mace, 1974). In areas where soils may be sensitive to nutrient loss, limiting cutting to light partial cuts may be necessary to prevent nutrient loss (Brown 1976).

Aber, et al. (1978) modeled changes in forest floor biomass and nitrogen cycling using various regimes of clear-cutting. A projected rotation that clear-cuts a forest each 30 years versus one on a 90 year cycle accumulates less forest floor biomass and may release more nitrogen to streams. Williams and Mace (1974) state that, in general, the more drastic the manipulation of the forest, the larger the corresponding release of nutrients, with minor manipulations causing little or no nutrient release. In their study of jack pine clear-cutting in Minnesota, summer logging involving whole tree removal was found to cause significantly more nutrient leaching than winter logging with only stem removal.

10.2.2.3 Temperature

Stream temperature is important in protecting aquatic life and because of its impact on dissolved oxygen and nutrients (Brown 1976). Stream temperatures vary depending on the presence of forested buffer strips adjacent to stream channels (Hornbeck, et al., 1986). Douglass and Swank (1975) concluded, "Stream temperatures are not increased by forest cuttings if a buffer strip is retained to shade the stream."

Kochenderfer and Aubertin (1975) found that clear-cuts on upper watershed areas did not increase stream temperature, as few stream channels occur in these areas. In lower watershed cuttings where trees were left adjacent to the stream channel, cuttings had no influence on stream temperature.

10.2.2.4 Summary

Studies indicate that erodibility of a watershed impacted by either natural disturbances or logging will remain low "as long as the disturbance does not involve severe and widespread disruption of the forest floor" (Bormann, et al., 1974). The relevant components of logging operations are skidding, log landing, and access road construction, where mineral soil may be exposed.

While increases in streamwater nutrients vary by type of cutting and watershed characteristics, the two key aspects of cutting that influence nutrient release are the location and extent of clearing and the response of forest regeneration. Even where openings are revegetated within four years by rapidly growing, early successional species, nutrient losses can still occur (Bormann, et al., 1974).

Studies have demonstrated the methods that will hold water temperature and turbidity increases within tolerable limits (Swank 1972). Patric (1978) states there is overwhelming evidence that neither the productivity of soils nor the quality of water is substantially lessened during or after responsibly managed harvests. Stone et al. (1979) report that if proper precautions are taken, water quality impacts from logging are essentially non-existent. Regarding timber harvesting, Stone (1973) concludes that "adverse impacts can be greatly reduced or entirely avoided by skilled planning and sufficient care."

10.3 Uneven-Aged Silviculture

10.3.1.1 Water Yields

While most of the trends summarized in the even-aged management water yields section above also hold true for uneven-aged management, the effects upon water yield vary. For example, uneven-aged management on north-facing slopes, removing conifers and involving significant percentages of basal area, will probably result in higher water yields than less intensive cuts removing hardwoods on south-facing slopes. However, either approach to uneven-aged management will likely result in smaller water yields than a comparable even-aged management approach. This is due to less dramatic changes in soil moisture and evapotranspiration caused by the smaller openings used in uneven-aged management. Adjacent vegetation and advance regeneration more quickly fill these smaller gaps. In addition, the higher ratio of edge to opening in selection system silviculture results in higher utilization of the additional soil moisture created by cutting. Hunt and Mader (1970) found that when two white pine forest plots at Quabbin Reservoir were thinned by 30% and 80%, soil moisture increased slightly to moderately and growth increased by 70% and 230% respectively. Hornbeck, et al. (1993) reported that when 24% of a basin was cut in one clearing it yielded twice the water of a similar basin where 33% of the forest was removed in scattered openings.

Douglass (1983) found that "partial cuttings were not as efficient for augmenting water yield as were complete cuttings." Storey and Reigner (1970) note:

> There are several ways we can manipulate vegetation to effect water savings. The obvious one is by heavy cutting of trees, thereby removing rainfall intercepting surfaces and removing the transpiring agent. According to considerable evidence our people have collected,

single tree selection cutting saves little or no water. The cutover area need not be large; cutting in blocks or strips or even group selection of trees to be removed will save water.

While it is clear that silvicultural systems employing partial cuttings yield less water than complete cuttings, partial cutting studies do show increased yields (Mrazik et al., 1980). For example, of the ten selection cut or thinning watershed experiments in the U.S. listed by More and Soper (1990), eight resulted in significant yields. The average annual yields for each of the first five years after cutting ranged from 0.4 to 2.3 area-inches. On average, selection/thinning resulted in a yield of 1 area-inch per year for the first five years after cutting. Hibbert (1967) reported results of seven selective cuttings in North Carolina and West Virginia in which all watersheds except one had a southerly exposure. The average annual yield for years measured after cutting was 1.13 area-inches. The lightest cuttings necessary to produce significant yield increases remove approximately 25% of the forest basal area (Kochenderfer and Aubertin 1975; Trimble, et al., 1974). Douglass and Swank (1972) assembled a model that predicts a first year water yield increase based on reduction in forest basal area. This model predicts that a 30% reduction in basal area will increase yields approximately 2-3 annual area-inches.

In predicting the significance of water yields to be derived from uneven-aged management, specific site characteristics of watersheds must be examined. For example, cuttings on north facing watersheds with deep soils will result in relatively larger yields. Using regression lines from Hibbert (1967), a one-third reduction in forest cover on a north-facing watershed is estimated to yield three times the streamflow of a similar cut on a south-facing watershed.

Yields from uneven-aged management should also be viewed in comparison to even-aged management and natural management. In general, yields from uneven-aged management should fall between those from even-aged management and natural management. Numerous studies have shown that water yield increases for the first year after cutting is roughly proportional to the percentage reduction in basal area of the forest cover (Douglass and Swank, 1972; Hewlett, 1982), although this reduction must exceed 25% to begin to result in a water yield increase. As forest areas regrow without further disturbance, these yields decline. Hibbert (1967) reports on three small watersheds (all less than 2,000 acres) in New York where an average of 47% of the watersheds was planted to conifers. After 25 years, the three watersheds averaged 5.3 area-inches less streamflow than prior to the planting. Another medium sized watershed (over 300,000 acres) that was passively managed for 38 years and on which average basal area doubled, showed a decrease in yield of 7.7 area-inches - equivalent to a 25% reduction.

Some of the largest yield increases resulting from clearcutting of 100% of a watershed were recorded on the Marcell Experimental Forest, Catchment #4, in Minnesota. This treatment involved cutting alone, with no subsequent herbicide treatment to suppress regeneration (as occurred on Hubbard Brook, Fernow, and Leading Ridge watershed experiments). At Marcell, even-aged clearcutting resulted in streamflow increases up to 70% within three years of cutting, and a range from 15-70% during all of the first 10 years following cutting. Other evidence shows potential decreases on unmanaged forests of up to 25%. Uneven-aged management falls in between these two approaches, but averages small yield increases (on the order of approximately 5% for the first few years after cutting). On Division watersheds, the maturing forest cover would probably produce fairly consistent yields under a naturally-managed approach, and small to moderate increases under either an uneven-aged or even-aged approach, depending largely on the proportion of any given watershed that was cut, and the pattern of that cutting.

10.3.1.2 Water Quality

Many of the principles underlying the potential for water quality impacts as a result of logging operations apply equally to even-aged and uneven-aged management. In order to avoid repetition, only the potential water quality impacts unique to uneven-aged systems will be reviewed in this section. As with even-aged management, the impacts upon water quality vary with intensity and location of management; intensity, layout, and maintenance of road systems; and planning and supervision of logging and woods roads operations (Lull and Reinhart 1967; Kochenderfer and Aubertin 1975; Hornbeck and Federer 1975).

Uneven-aged systems remove single trees and small groups of trees. In a temperate-region forest study of gap-size impacts on nitrates, Parsons et al. (1994) measured extractable nitrate in soil plots. Within a lodgepole pine forest in Wyoming, gaps were created by removing 1, 5, 15, or 30 trees. The authors found that, compared with adjacent undisturbed forest, gaps created by removing 1 or 5 trees had no increase in nitrate. The 15-tree gaps had higher nitrate levels, and 30-tree gaps had nitrate levels 2-3 times higher than the 15-tree gaps. This same stand was previously thinned with no increase in nitrates, and clear-cut with soil nitrate increases of 10-40 times those in adjacent undisturbed forest. The authors recommend selective harvesting if nitrogen availability is of concern on a site. Stone (1973) notes:

> Any management practices that reduce vigor of the residual vegetation or delay regrowth and regeneration - such as scarification, excessive herbicide application, or maintenance of excessive deer herds - could increase loss rates [nitrate leaching] above those observed on the harvest clearcuts. On the other hand, greater surface soil shading, as by partial cutting methods, narrow stripcuts, increased cover density on clearcuts, or any means of hastening regrowth, would reduce losses [nitrate leaching] even more.

Satterlund and Adams (1992, p.278-279) discuss the influence of cutting pattern:

> Pattern has a strong influence on the nature and degree of response to any treatment that modifies a watershed, whether it is the killing or removal of vegetation, compaction or exposure of soil, or rehabilitation of disturbed lands. Pattern, along with type and amount of treatment, is one of the few factors subject to a high degree of management control…By definition, responses to modification of source areas are more pronounced than the same modifications of nonsource areas, for source areas are the portion of any watershed that is tightly linked to the stream system. Any treatment effect is readily transmitted to the channel with little delay or buffering. Similarly, concentrated treatments tend to have greater effects than the same amount of treatment dispersed widely over a watershed. There is greater opportunity to buffer many small dispersed treatments than one large one. In addition, small units may show less response per unit area treated than large ones because of edge effects…For example, if 25% of a forest in several different watersheds was removed by different methods ranging from a singe clearcut to smaller, more dispersed patch cuts or group selection or a uniformly dispersed single-tree selection, the water yield response might range from substantial to negligible, respectively.

Trimble, et al. (1974), in comparing management systems, state that water quality is ordinarily maximized on forest land by maintaining an unbroken tree and litter cover. The City of Baltimore's forest management utilizes the selection system because “although this [selection system] is not the most economical system of cutting to use, it leaves sufficient cover to protect the watershed...”(Hartley 1975).

Research has shown clearly that where stream shading is unaffected, stream temperature will not change (Douglass and Swank 1975; Hornbeck et al., 1986; Kochenderfer and Aubertin 1975). With little significant impact upon temperature and nutrient streamwater parameters, the chief potential impact of uneven-aged management systems is turbidity. However, increased turbidity appears to be less of a concern with uneven-aged management, due to the lighter cutting practices and the amount of forest cover. For example, a comparison study of two watersheds at the Fernow Experimental Forest in West

Virginia showed only slight elevations of particulates after three selection cuts during the 1950s and 1960s (cuts included 13%, 8%, and 6% of basal area) as compared to an adjacent undisturbed watershed. In a separate study, Corbett and Spencer (1975) reported no turbidity increases from a thinning operation.

One area of potential concern regarding traditional uneven-aged systems is that cutting cycles are often more frequent, meaning more frequent forest entry and more miles of access roads in use at any given time (Stone et al., 1979). However, the actual impacts will depend upon the uneven-aged method adopted. For example, in uneven-aged forests managed for water supply purposes, trees can be grown on longer rotations and longer cutting cycles. Rhey Solomon, water resource manager for the U.S. Forest Service notes "...the way to keep the water flowing and safeguard the forest is to rotate management throughout the watershed" (American Forest Council 1986).

11 Appendix II: Uncommon Plants Potentially Occurring on DWSP Properties and Habitats in Which Rare Plant Species are Likely to be Found (Searcy, 1996)

11.1 Uncommon Plants Potentially Occurring on DWSP Properties

NOTE: For Status, E = endangered, T = threatened, SC = special concern, WL = watch list

Family	Species	Common Name	Status	Flowering
Apiaceae	*Conioselium chinense*	Hemlock Parsley	SC	Jul/Sep
Apiaceae	*Sanicula trifoliata*	Trefoil Sanicle	WL	Jun/Oct
Asclepiadaceae	*Asclepias verticillata*	Linear-leaved Milkweed	T	May/Jul
Asteraceae	*Aster radula*	Rough aster	WL	Jun/Aug
Brassicaceae	*Arabis drummondii*	Drummond's Rock-cress	WL	May/Aug
Brassicaceae	*Arabis missouriensis*	Green rock-cress	T	Jul/Oct
Brassicaceae	*Cardamine bulbosa*	Spring Cress	WL	Jun/Aug
Caryophyllaceae	*Stellaria borealis*	Northern Stitchwort	WL	May/Aug
Cyperaceae	*Eleocharis intermedia*	Intermediate spikerush	T	Aug/Oct
Cyperaceae	*Scirpus ancistrochaetus*	Barbed-bristle bulrush	E	Jun/Jul
Fabaceae	*Lupinus perennis*	Wild Lupine	WL	May/Jul
Gentianaceae	*Gentiana andrewsii*	Andrew's Bottle Gentian	T	Apr/Jun
Gentianaceae	*Gentiana linearis*	Narrow-leaved Gentian	WL	Jun/Aug
Haloragaceae	*Myriophyllum alterniflorum*	Alternate leaved Milfoil	T	Jun/Aug
Juncaceae	*Juncus filiformis*	Thread rush	T	Aug
Lentibulariaceae	*Utricularia minor*	Lesser bladderwort	WL	May/Nov
Liliaceae	*Smilacina trifolia*	Three-leaved Solomon	WL	Apr/Jun
Loranthaceae	*Arceuthobium pusillum*	Dwarf mistletoe	SC	May/Sep
Orchidaceae	*Coeloglossum viride v. bracteata*	Frog orchid	WL	May/Sep
Orchidaceae	*Corallorhiza odontorhiza*	Autumn coralroot	SC	Apr/Jul
Orchidaceae	*Cypripedium calceolus v. parviflorum*	Small Yellow Lady Slipper	E	May/Aug
Orchidaceae	*Cypripedium calceolus v. pubescens*	Large Yellow Lady Slipper	WL	Jun/Sep
Orchidaceae	*Isotria medeoloides*	Small whorled pogonia	E	May/Jul
Orchidaceae	*Platanthera hookeri*	Hooker's Orchid	WL	Mar/Jun
Orchidaceae	*Platanthera macrophylla*	Large leaved Orchis	WL	Apr/Jul
Orchidaceae	*Platanthera. flava var. herbiola*	Pale Green Orchis	T	Jun/Sep
Orchidaceae	*Triphora trianthophora*	Nodding Pogonia	E	Jul/Sep
Poaceae	*Panicum philadelphicum*	Philadelphia Panic Grass	SC	Jul
Poaceae	*Trisetum pensylvanica*	Swamp Oats	T	Aug/Oct
Poaceae	*Trisetum spicatum*	Spiked False Oats	E	Jul/Sep
Ranunculaceae	*Ranunculus alleghaniensis*	Allegheny buttercup	WL	Jun/Sep
Sparganiaceae	*Sparganium angustifolium*	Narrow-leaved Bur Weed	WL	May/Nov
Urticaceae	*Parietaria pensylvanica*	Pellitory	WL	Aug/Sep

11.2 Habitats in Which Rare Plant Species are Likely to be Found

Working with the University of Massachusetts herbarium, the Division has also identified the following habitat/rare species relationships to assist in the development of more comprehensive lists.

Forested Areas:

Rich Mesic Woods (less acid - rich herbaceous layer. Indicators: *Acer saccharum*, *Fraxinus americana*, *Adiantum pedatum*, *Asarum canadense*)

Species	Common name	Comments
Acer nigrum	Black Maple	
Cerastium nutans	Nodding Chickweed	
Coeloglossum viride v. bracteata	Frog orchid	to dry rocky woods
Corallorhiza odontorhiza	Autumn coralroot	to dry/seasonally wet streamlets
Cypripedium calceolus v. pubescens	Large Yellow Lady Slipper	slopes and talus
Equisetum pratense	Horsetail	sandy places
Panax quinquefolius	Ginseng	talus and base of ledge areas
Platanthera hookeri	Hooker's Orchid	often rocky or swampy
Ranunculus alleghaniensis	Allegheny buttercup	rocky
Ribes lacustre	Bristly Black Current	
Sanicula canadensis	Canadian Sanicle	
Sanicula gregaria	Long-Styled Sanicle	
Sanicula trifoliata	Trefoil Sanicle	

Moist Coniferous / Pine Woods

Species	Common Name	Comments
Goodyera repens	Dwarf Rattlesnake Plantain	pine woods
Moneses uniflora	One-Flowered Pyrola	moist rich woods

Hemlock-Northern Hardwoods

Species	Common Name	Comments
Isotria medeoloides	Small whorled pogonia	vernally moist areas
Platanthera macrophylla	Large leaved Orchis	moist ravines, limey
Rhododendron maximum	Rhododendron	hemlock island in swamp
Triphora trianthophora	Nodding Pogonia	depressions under beech
Viola renifolia	Kidney Leaved Violet	damp rich woods

General Habitat:

Boulder/Talus Slope/Ledges

Species	Common name	Comments
Adlumia fungosa	Climbing Fumitory	Shaded limey talus
Amelanchier sanguinea	Roundleaf Shadbush	Ledges & ridge tops
Arabis drummondii	Drummond's Rock-cress	
Arabis missouriensis	Green rock-cress	open rock and scree
Chenopodium gigantospermum	Maple-leaf Goosefoot	shaded dry ledges
Clematis occidentalis	Purple Clematis	exposed ledges & talus
Parietaria pensylvanica	Pellitory	shaded shelves
Pinus resinosa	Red Pine	exposed, rocky ridge tops

Species	Common name	Comments
Rosa blanda	Smooth rose	dry to mesic rocky slopes
Trisetum spicatum	Spiked False Oats	Exposed

Sandplain / Open Meadow

Species	Common name	Comments
Asclepias verticillata	Linear-leaved Milkweed	open rocky
Eragrostis capillaris	Lace Love Grass	open sandy soil
Gentiana andrewsii	Andrew's Bottle Gentian	open/meadow
Liatris scariosa var novae-angliae	New England Blazing Star	sandy open pine wds.
Lupinus perennis	Wild Lupine	sandy open pine wds.
Paspalum setaceum	Paspalum	sandy soil
Penstemon hirsutus	Beard-Tongue	dry or rocky ground
Polygala verticillata	Whorled Milkwort	open woods/old field/stony shores

Aquatic Habitats:

Ponds / Streams

Species	Common name	Comments
Aster tradescantii	Tradescant's Aster	Fields/swamps
Betula nigra	River Birch	Swamps & stream banks
Cardamine longii	Long's Bitter-cress	Swampy streams
Eleocharis intermedia	Intermediate spikerush	Exposed shores
Juncus filiformis	Thread rush	Meadows/springs/riverbank
Megalodonta beckii	Water marigold	
Myriophyllum alterniflorum	Alternate leaved Milfoil	
Nuphar pumila	Tiny Cow-Lily	
Panicum philadelphicum	Philadelphia Panic Grass	Exposed shores
Scirpus ancistrochaetus	Barbed-bristle bulrush	Swales and shores
Sparganium angustifolium	Narrow-leaved Bur Weed	
Sparganium fluctuans	Bur-Reed	
Utricularia minor	Lesser bladderwort	Seepy stream sides
Utricularia resupinata	Bladderwort	Swamps, swales, shores

Seeps / Seepage Areas

Species	Common name	Comments
Cardamine bulbosa	Spring Cress	
Conioselium chinense	Hemlock Parsley	Black ash seepage swamps
Cypripedium calceolus v. parviflorum	Small Yellow Lady Slipper	Black ash seepage swamps
Elatine americana	American Waterwort	Wet clay soil
Mimulus moschatus	Muskflower	Open seepage area
Pedicularis lanceolata	Lousewort	Open areas
Platanthera flava var. herbiola	Pale Green Orchis	Vernal streams in hardwoods
Stellaria borealis	Northern Stitchwort	
Trisetum pensylvanica	Swamp Oats	

Bogs / Boggy Areas

Species	Common name	Comments
Arceuthobium pusillum	Dwarf mistletoe	On Black Spruce

Species	Common name	Comments
Arethusa bulbosa	Arethusa	
Aster radula	Rough aster	beaver meadows/swamp borders
Gentiana linearis	Narrow-leaved Gentian	boggy meadows
Scheuchzeria palustris	Pod Grass	
Smilacina trifolia	Three-leaved Solomon	boggy woods
Viola nephrophylla	Northern Bog Violet	
Xyris montana	Northern Yellow-eyed grass	

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13 Glossary of Terms

Listed in alphabetical order below are terms and definitions that appear in this and other DWSP land management plans. Most of those that relate to forests and forestry are derived from "Terminology of Forest Science, Technology, Practice and Products" (Society of American Foresters, 1971).

age class: one of the intervals, commonly 10 years, into which the age range of tree crops (and sometimes other vegetation) is divided for classification.

advance regeneration: in silvicultural terms, young trees that have become established naturally in a forest, in advance of regeneration cutting; may become established following "preparatory" cuts.

area inch; acre inch: used to describe changes in water yield from a given area of land. For instance, if a change in vegetation results in an increase of one acre inch in water yield, this translates to 43,560 sq ft per acre x 1/12 ft yield = 3,630 cubic feet per acre; 3,630 cu ft / 7.5 gals per cu ft = 484 gallons additional yield per acre.

basal area: the area in square feet of the cross section of a tree taken at 4.5 feet above the ground.

basin; subbasin: the land area from which all water flows to a single, identified water source, such as a stream, a river, or a reservoir. Subbasin is used to refer to the basin of a tributary, or lower *order* stream (the higher the order, the greater the area drained).

"beaver pipe"; flow control pipe: generally a length of culvert that is extended into a beaver pond at or near the top of the beaver dam, in order to maintain the pond level at a particular level.

Best Management Practices (BMPs) or Conservation Management Practices (CMPs): in natural resources management, a set of standards that have been designed for an activity, and often a region, to protect against degradation of resources during management operations.

biological diversity (biodiversity): a measure, often difficult to quantify, of the variety and abundance of plant and animal species within a specified area, at the genetic, species, and landscape level of analysis. The 1992 UN Convention on Biological Diversity defined biodiversity as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems."

biomass: the total quantity, at a given time, of living organisms of one or more species per unit area (species biomass) or of all the species in a community (community biomass)

Conservation Management Practices: Canadian term used synonymously with "best management practices". See definition above for Best Management Practices.

conservation restriction; conservation easement: a legal agreement between a landowner and another party whereby, for a consideration, the landowner deeds certain specified rights (such as development of the property) to the other party, but retains ownership of the land and other specified rights to its use. Individual agreements vary, but the general result is protection of land from conversion to new uses, without transfer of ownership. When the Division purchases conservation restrictions, it also limits or retains the right to approve certain agricultural and silvicultural practices.

Continuous Forest Inventory (C.F.I.): a method of forest inventory in which trees on permanent sample plots are remeasured at periodic intervals to provide data used to estimate forest growth and condition. The Division's Continuous Forest Inventory on the Ware River and Quabbin watersheds is composed of 1/5-acre permanent plots located on a ½-mile grid and is remeasured every 10 years.

cutting cycle: the frequency with which silvicultural cuttings are conducted in any given area. Cutting cycle is a subunit of "rotation," which is determined either by the maximum life of the existing overstory, or by a predetermined maximum age imposed on the area.

Cryptosporidium: a coccidian protozoan parasite found in humans and various wild and domestic animals that can be transmitted via water and often causes serious intestinal illness. While the epidemiology and transmission of *Cryptosporidium* are similar to *Giardia*, its cysts are smaller than the cysts of other protozoa, and thus may be more difficult to remove from water supplies.

diameter at breast height; DBH: the diameter of a tree, outside the bark, taken at 4.5' above the ground, generally in inches and fractions.

diverse; diversity: in this plan, the term is most often used to refer to forest composition, and refers to both height or size diversity in trees, seeking a minimum of three distinct layers (understory, midstory, and overstory), and to diversity of species composition, with a general goal of avoiding monocultures and working to include a range of site-suited species throughout the forest.

disturbance-sheltered: areas that are physically (based on slope and aspect) "sheltered" from the influence of a catastrophic New England hurricane blowing from the southeast, based on a model developed at the Harvard Forest. The most sheltered areas are steep slopes facing northwest.

edge effect: this term has traditionally been used to describe the increased richness of flora and fauna found where two habitat types or communities meet. More recently, the term has also been used to refer to the increased nest predation and parasitism that often occurs near these boundaries.

endogenous disturbance: disturbance that originates within the ecological community. For example, a single tree that succumbs to a root-rot fungus and falls to the ground, breaking off several other trees on the way, creates an endogenous disturbance. While the proximal cause of the treefall may be wind or accumulation of snow and ice, the primary cause is still considered endogenous in this instance. (See "exogenous disturbance.")

even-aged: an area of forest composed of trees having no, or relatively small, differences in age. By convention the maximum difference admissible is generally 10 to 20 years, though with rotations of 100 years or more, differences up to 30% of the rotation may be admissible.

exogenous disturbance: disturbance that originates from forces outside of the ecological community. For example, storms that carry high winds can cause large-scale treefall well in advance of normal senescence and decay. The cause of the disturbance is therefore considered exogenous. (See "endogenous disturbance.")

feller-buncher; feller-buncher-processor: logging machines that grasp a tree to be cut or "felled," sever it at the stump with either a saw or hydraulic shears, and directionally drop it to the ground. Some machines can accumulate, or "bunch" several trees before releasing them. The most complex machines are also capable of delimbing and sawing trees into predetermined lengths (processing).

forest canopy: the more or less continuous cover of branches and foliage formed collectively by the crowns of adjacent trees and other woody growth.

forest fragmentation: the separation of a previously contiguous forested area into smaller, discontinuous patches or "fragments." This can isolate wildlife populations and may result in forested areas too small to meet the habitat requirements of some species.

forwarder: a logging machine used to "forward" logs from the woods to a landing. A forwarder differs from a skidder in that the logs are hydraulically loaded onto the machine and carried, rather than skidded, through the woods.

group selection: a regeneration method in which patches (generally less than one to two acres) of selected trees are removed to create openings in the forest canopy and to encourage the reproduction and development of uneven-aged stands.

G.I.S.; Geographic Information System: a computer-based analysis and mapping system for spatially-linked data sets.

***Giardia*:** A protozoan parasite found in humans and various wild and domestic animals that can be transmitted via water and often causes serious intestinal illness.

hurricane exposure ("exposed," "intermediate," "sheltered"): generally used in Division land management plans to mean physical exposure of a site to catastrophic hurricane winds. Research at the Harvard Forest in Petersham, MA provides a predictive model of the impact of a typical New England hurricane, based upon site, slope, and aspect. Damage from an actual hurricane depends upon many factors, including the type and size of vegetation present.

intermediate cut: cutting of trees in a stand during the period between establishment and maturity. Objectives may include the improvement of vigor by reducing competition or the manipulation of species composition. Regeneration may occur following intermediate cuts, but it is incidental to the objectives.

irregular shelterwood: similar to the shelterwood silvicultural system except that overstory removals are protracted, taking as long as half the rotation, so that the resulting new stand is quite uneven-aged (wide intervals between the oldest and youngest trees) and mimics the multi-storied effect of strictly uneven-aged systems.

log landing: a clearing of variable size to which logs, pulp, and/or firewood are skidded or forwarded during a logging operation, in order to facilitate their processing or further transport by truck.

mast: the fruit and seeds of trees and shrubs. Mast constitutes an important food source for many wildlife species. Hard mast includes hard-shelled seeds such as acorns and hickory nuts. Soft mast includes seeds with a fleshy cover such as berries.

milacre: one one-thousandth of an acre. Milacre plots are used in the collection of some data on the Division watersheds; for example, regeneration inventory is taken on circular, milacre plots, which are 89.4 inches in diameter.

mineral soil: any soil consisting primarily of mineral material (sand, silt, and clay) rather than organic matter.

multi-storied forest; multi-layered forest: a forest containing a distinct understory, midstory, and overstory. From a watershed perspective, these layers provide, respectively: immediate response to disturbance, vigorous uptake of nutrients, and deep filtration of air-borne and precipitative pollutants.

naturally managed: the results of a decision to allow natural disturbances and processes to prevail by adopting a minimal management approach that protects forests from development or other land use changes and possibly human-caused fire, but which includes vegetation management only where it clearly counteracts a negative result from previous human disturbances.

preparatory cutting: removing trees near the end of a rotation so as to open the canopy and enlarge the crowns of seed bearers, with a view to improving conditions for seed production and the establishment of natural regeneration.

protected: refers to areas of the watershed that, according to the Harvard Forest model of hurricane disturbance, would suffer minimal damage from the recurrence of a hurricane similar to that of 1938, due primarily to topography and orientation.

protection forest: an area, wholly or partly covered with woody growth, managed primarily to regulate stream flow, maintain water quality, minimize erosion, stabilize drifting sand, or to exert any other beneficial forest influences.

regeneration: the replacement or renewal of a forest stand by natural or artificial means; also, the young tree crop itself. Natural regeneration: young plants produced from natural seed fall or from stump or root sprouting in openings formed after existing plants are cut, burned or blown over. Artificial regeneration: planting or purposefully seeding trees in a previously harvested area.

regeneration cut: any removal of trees intended to assist regeneration already present or to make regeneration possible.

riparian: pertaining to the bank of a stream or other water body. Riparian vegetation grows in close proximity to a watercourse, lake, swamp, or spring, and is often dependent upon its roots reaching the water table.

rotation: in even-aged silviculture, rotation is the planned number of years between the formation or regeneration of a crop or stand and its final cutting at a specified stage of maturity. If it has been established, the maximum age to which trees are grown in an uneven-aged system, or the average age to which trees are grown before cutting, might be considered the stand's rotation age. But there is no point in the life of a stand under uneven-aged management at which all trees are deliberately regenerated at once.

salvage; salvage cutting: the removal of trees damaged by fire, wind, insects, disease, fungi, or other injurious agents before their timber becomes worthless. In some situations, the motivation for removal is the reduction of fuel loading and fire hazard.

sanitation cutting: a proactive removal of diseased or highly susceptible trees in order to slow or halt the spread of a disease or other destructive agent.

seep: a wet area, generally associated with groundwater seepage, that is important to wildlife because it remains unfrozen, and generally uncovered, during periods when the ground is otherwise snow-covered, which makes it easier for wildlife to forage.

selection system: a regeneration method designed to create and perpetuate an uneven-aged stand. Trees are harvested singly or in small groups. A predetermined number of trees in each diameter class is removed at each harvesting entry in order to maintain a particular age-distribution across the stand.

sere; seral: the series of successional stages in an ecosystem, from the pioneer stage through the climax. (See "succession.")

shelterwood: term generally refers to a variety of even-aged silvicultural systems in which, in order to provide a source of seed, protection for regeneration, or a specific light regime, the overstory (the shelterwood) is removed in two or more successive shelterwood cuttings. The first is ordinarily the seed cutting (though it may be preceded by a preparatory cutting) and the last is the final cutting, while any intervening cuttings are termed removal cuttings. Where adequate regeneration is already present, the overstory may be removed in one cutting, resulting in a method referred to as a one-cut shelterwood. Some applications of the shelterwood leave a portion of the stocking indefinitely and develop two or more age classes as a result. These are sometimes referred to as uneven-aged methods (see "irregular shelterwood" definition above).

silviculture: generally, the science and art of cultivating (i.e., growing and tending) forest crops, based on a knowledge of silvics. Silvics is the study of the life history and general characteristics of forest trees and stands, with particular reference to environmental factors affecting growth and change. More particularly, silviculture is the theory and practice of controlling the establishment, composition, constitution, and growth of forests.

site: in forestry, the combination of environmental factors that affect the ability of a species to grow and persist, including soil characteristics, aspect, altitude and latitude, and local climate.

site index: the ability of a given site to grow a given species. As height growth is generally not density dependent, a common forestry site index is the height to which a given species will grow on the site in fifty years (so that a site with a red oak site index of 65 will grow red oak to that height in fifty years).

site preparation: in silviculture, any of a variety of treatments of a site that are intended to enhance regeneration success. A common goal of these treatments is to remove enough of the accumulated organic layers above the mineral soil so as to expose that soil and enhance the ability of seeds that fall on it to germinate and grow. The skidding of logs during a harvesting operation is often sufficient site preparation.

site-suited: species that have evolved to take advantage of a particular type of site. Where species are planted on other sites, they may succumb prematurely to disturbance or disease. Red pine grows and persists well on deep, sandy soils, where root rots are less common, but may become excessively prone to wind and/or root rotting diseases on the moist agricultural soils on which they were typically planted on Division properties.

skidder: logging machine used to "skid" logs from the woods to a landing or a forwarder road. Logs are either winched by cable to the skidder (cable skidder), or lifted on one end by a hydraulic grapple (grapple skidder), and then dragged.

stand: a community of trees possessing sufficient uniformity as regards composition, age, spatial arrangement, or condition to be distinguishable from adjacent communities, and therefore forming a distinct silvicultural or management entity.

stocking: in forestry, the extent to which a site is occupied by trees compared to the maximum theoretical occupation possible at a given stand age; a relative measure of stand density. Most commonly measured as basal area per acre, stocking is often related directly to crown closure, as a site is considered fully occupied when crown closure is complete. As crowns can be of very different sizes among species and tree ages within stands, average diameter (dbh) and total number of trees of a "fully stocked" site is variable.

stream order: a classification of streams within watersheds. Small streams at the uppermost level of stream systems are labeled "first-order"; two first-order streams join to form a "second-order" stream; two second-order streams join to form a "third-order" stream, etc.

structures: the presence, size, and physical arrangement of vegetation in a stand. Vertical structure refers to the variety of plant heights, from the canopy to the forest floor. Horizontal structure refers to the types, sizes, and distribution of trees and other plants across the land surface. Forestlands with substantial structural diversity provide a variety of niches for different wildlife species, as well as a measure of resistance and resilience in the face of natural disturbances.

succession: the gradual supplanting of one community of plants by another, the sequence of communities being termed a "sere" and each stage "seral." Succession is "primary" (by "pioneer species") on sites that have not previously borne vegetation, "secondary" after the whole or part of the original vegetation has been supplanted, "allogenic" when the causes of succession are external to and independent of the community (e.g., a storm or climate change), and "autogenic" when the developing vegetation is itself the cause. "Early succession" generally refers to the pioneer stages and species that follow disturbance, while "late succession" refers to stages and species that occur as an area continues to develop undisturbed for long periods.

thinning: an intermediate silvicultural treatment, generally with the goal of altering the forest composition and/or improving the growing conditions for the residual trees, regardless of associated regeneration effects.

timber stand improvement (TSI): intermediate treatments, including the removal of brush and cull trees, that leave a stand of good quality trees of the desired species.

turbidity: a water quality measure that is most commonly derived by measuring the proportion of a given amount of light that is deflected by suspended/dissolved sediments in a water sample, giving an indirect measure of these sediments. Most common unit is the Nephelometric Turbidity Unit, NTU.

uneven-aged: a forest, crop, or stand composed of intermingling trees that differ markedly in age. By convention, a minimum difference between tree ages of 25% of the maximum age to which trees are grown is generally accepted. Some texts require a minimum of three distinct age classes for a stand to qualify as "uneven-aged."

vernal pool: a temporary body of fresh water that is or becomes isolated while containing water, is utilized by indicator species, and has a wet-dry cycle that precludes permanent populations of fish. The absence of fish populations is critical to the breeding success of some species that utilize vernal pools. Vernal pools in Massachusetts support a number of rare or endangered animal species, and are therefore important habitats that receive regulatory protection once certified. The Division provides this protection to all identified pools, whether or not they have been certified.

watershed protection forest: an area, wholly or partly covered with woody growth, managed primarily to maintain water quality, regulate stream flow, minimize erosion, or exert any other beneficial forest influences.

wetland: generally refers in the Division land management plans to areas defined as "wetlands" by MGL ch.131, s 40 (the "Wetlands Protection Act") and 310 CMR 10.00 (the "Wetlands Protection Regulations"). The Division definitions of wetlands will be updated as these statewide regulations are revised.